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TRANSCAL v.2.3 USER'S Manual

R. Cunningham

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Contractor Report

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TRANSCAL v.2.3
USERS MANUAL

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CONTRACTOR REPORT

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Abstract

This report is a user manual for the transducer calibration software, referred to as TRANSCAL, for use in the Defence Research Establishment Atlantic (DREA) calibration facilities. This software was developed in three phases. In Phase 1, procedures for the transmitting voltage response and receiving response using swept pulse or continuous wave (CW) were developed. In Phase 2, additional calibration procedures were added for directional response measurements and reciprocity measurements. An interface to a servomotor control system for elevation positioning was added. Also in Phase 2, the existing Brickwall filter was replaced by a Krohn-Hite Model 3988 filter, resulting in software modifications. The user interface front panels were re-designed to enable use of a 17-inch display. In Phase 3, a standalone admittance/impedance measurement mode was added. The user manual was revised to include the new measurement mode, as well as consolidate the user manuals resulting from the two previous phases.

Résumé

Ce rapport est un manuel d'utilisateur pour le logiciel d'étalonnage de transducteurs, TRANSCAL, utilisé dans les facilités d'étalonnage du Centre de recherches de la défense – Atlantique (CRDA). Le logiciel a été développé en trois phases. Durant la phase I, les procédés pour la sensibilité par volt et la sensibilité de reception utilisant la fréquence de balayage d'une sinusoïdale, une impulsion ou une onde continu ont été développé. Dans la deuxieme phase, d'autres procédés d'étalonnage ont été ajouté pour mesurer la directivité et pour faire des mesures en utilisant la méthode de réciprocité. Une interface au systeme de controle du servomoteur on été ajouté. En plus, durant la phase II, le filtre Brickwall a été remplacé par un filtre Krohn-Hite modele 3988 qui a entrainé des modifications au logiciel. L'interface de l'utilisateur a été refait pour permettre l'utilisation d'un écran de 17 pouces. Dans la phase III, un mode isolé pour mesurer l'admittance et l'impédance a été ajouté. Le manuel de l'utilisateur a été revisé pour inclure les nouvelles modes de mesure en plus de consolider les manuels des deux prenieres phases.

Contents

Abstract/resumé / ii
Contents / iii
Figures and Tables / vii

Introduction / xi

About TRANSCAL / xi
Special features / xii
System requirements / xiii
About this manual / xiii
  Organization of this manual / xiv
  Conventions used in this manual / xiv
Associated documents / xiv

Part 1 Concepts

1 Data Acquisition / 1-1

Transducers / 1-2
Signal conditioning / 1-3
Amplification / 1-3
Isolation / 1-3
Filtering / 1-3
Data acquisition hardware / 1-4
Analog inputs / 1-4
Digital I/O / 1-6
Timing I/O / 1-6
Data acquisition triggering / 1-6

2 Transducer Calibration / 2-1

Overview / 2-1
Hydrophone calibration using tone burst and/or CW / 2-1
Projector calibration using tone burst and/or CW / 2-2
Hydrophone calibration using pseudo-random noise / 2-2
Measurement of transducer directivity patterns / 2-2
Absolute calibration using the reciprocity method / 2-3
Measurement of transducer admittance and impedance / 2-3

Part 2 Procedures

3 Hardware Installation and Wiring / 3-1

Nubus board installation / 3-1
Peripheral configuration / 3-3
Wiring / 3-4
Switch settings / 3-6

4 Software Installation / 4-1

Required system configuration / 4-1
Organization of the TRANSCAL system / 4-2
Installation procedure / 4-3

5 Using TRANSCAL / 5-1

Starting TRANSCAL / 5-1
Setting the calibration folder / 5-3
Selecting the standard hydrophone calibration / 5-5
Setting the calibration frequency range / 5-7
Setting the projector drive levels / 5-9
Setup the pulse timing / 5-10
Setup the elevation / 5-12
Modal Controls / 5-13
Current Settings / 5-14
Calibration Data Acquisition / 5-20
Acquired data graphs / 5-21
Acquiring the calibration data / 5-22

6 Using Transmit Response Mode / 6-1

Starting Transmit Response using tone pulse or CW / 6-1
Transmit Response Calibration step-by-step / 6-2
Controls and indicators / 6-3
Getting results / 6-8

7 Using Receiving Response Mode / 7-1

Starting Receiving Response using tone pulse or CW / 7-1
Receiving Response Calibration step-by-step / 7-1
Controls and indicators / 7-3
Getting results / 7-6

8 Using Directional Response Mode / 8-1

Starting Directivity / 8-1
Directivity Response Calibration step-by-step / 8-2
Controls and indicators / 8-3
Selecting the calibration frequency range / 8-10
Getting results / 8-11

9 Using Reciprocity Mode / 9-1

Starting Receiving Response using tone pulse or CW / 9-1
Reciprocity Calibration step-by-step / 9-2
Controls and indicators / 9-3
Getting results / 9-7

10 Using Standalone Admittance Mode / 10-1

Starting Admittance Mode using tone pulse or CW / 10-1
Admittance Calibration step-by-step / 10-2
Controls and indicators / 10-3
Getting results / 10-5

Part 3 Appendixes / 91

Appendix A Sample Results / A-1

Transmitting Voltage Response plot / A-3
Transmitting Current Response plot / A-5
Transmitting Voltage Response data file / A-7
Admittance plot / A-9
Impedance plot / A-11
Receiving Response plot / A-13
Receiving Response data file / A-15
Directional Response polar plot / A-17
Directional Response cartesian plot / A-19
Directional Response data file / A-21
Reciprocity Reciprocal Transducer Receiving Response plot / A-23
Reciprocity Transmit Voltage Response plot / A-25
Reciprocity Transmit Current Response plot / A-27
Reciprocity Hydrophone Receiving Response plot / A-29
Reciprocity calibration data file / A-31

Figures and Tables

Chapter 1 Data Acquisition / 1-1

Figure 1-1 A typical data acquisition system / 1-2

Chapter 3 Hardware Installation and Wiring / 3-1

Figure 3-1 NI-DAQ control panel / 3-2
Figure 3-2 TRANSCAL peripherals/ 3-3
Figure 3-3 Macintosh Quadra 900 NuBus connections / 3-4
Table 3-1 NB-A2000 connections / 3-4
Table 3-2 NB-TIO-10 connections / 3-5
Table 3-3 RTS 3510B connections / 3-5
Table 3-4 Krohn-Hite 3988 connections / 3-6
Table 3-5 Wavetek 296 connections / 3-6

Chapter 4 Software Installation / 4-1

Figure 4-1 TRANSCAL VI organization / 4-2

Chapter 5 Using TRANSCAL / 5-1

Figure 5-1 TRANSCAL startup icon / 5-1
Figure 5-2 TRANSCAL front panel / 5-2
Figure 5-3 Select logging folder dialog / 5-3
Figure 5-4 Select logging folder dialog with folder open / 5-4
Figure 5-5 Standard Hydrophone Sensitivity front panel / 5-5
Figure 5-6 Selecting a new standard hydrophone / 5-6
Figure 5-7 Setting the frequency range / 5-8

Figure 5-8 Setting the projector drive levels / 5-9
Figure 5-9 Setting the pulse specifications / 5-10
Figure 5-10 Setting the elevation / 5-12
Figure 5-11 CAL SEQUENCE front panel / 5-20
Figure 5-12 Sampled data graphs / 5-21

Chapter 6 Using Transmit Response Mode / 6-1

Figure 6-1 Transmit Response front panel / 6-1
Figure 6-2 Modal controls / 6-3
Figure 6-3 Transmit Response graph / 6-4
Figure 6-4 Selecting TVR/TIR graph / 6-5
Figure 6-5 Admittance/Impedance graph / 6-6
Figure 6-6 Selecting Admittance/Impedance graph / 6-7
Figure 6-7 Display Mode Controls / 6-7
Figure 6-8 Results dialog / 6-8

Chapter 7 Using Receive Response Mode / 7-1

Figure 7-1 Receiving Response front panel / 7-1
Figure 7-2 Modal controls / 7-3
Figure 7-3 Receiving Response graph / 7-4
Figure 7-4 Hydrophone sensitivity graph controls / 7-5
Figure 7-5 Display Mode Control / 7-5
Figure 7-6 Results dialog / 7-6
Figure 7-17 Select logging folder dialog / 89

Chapter 8 Using Directional Response Mode / 8-1

Figure 8-1 Directivity Response front panel / 8-1
Figure 8-2 Modal controls / 8-3
Figure 8-3 Directional Response polar graph / 8-4
Figure 8-4 Directional Response cartesian graph / 8-5
Figure 8-5 Display Mode Control / 8-5
Figure 8-6 Current Settings controls and indicators / 8-6
Figure 8-7 Directivity controls and indicators / 8-9
Figure 8-8 Setting the frequency range / 8-10
Figure 8-9 Results dialog / 8-11
Figure 8-16 Select logging folder dialog / 27

Chapter 9 Using Reciprocity Mode / 9-1

Figure 9-1 Reciprocity front panel / 9-1
Figure 9-2 Modal controls / 9-3
Figure 9-3 Receiving Response graph / 9-5
Figure 9-4 Hydrophone sensitivity graph controls / 9-6
Figure 9-7 Results dialog / 9-7

Chapter 10 Using Standalone Admittance Mode / 10-1

Figure 10-1 Admittance/Impedance front panel / 10-1
Figure 10-2 Selecting Admittance/Impedance graph type / 10-3
Figure 10-3 Display Mode Controls / 10-4
Figure 10-4 Cable Effects Controls / 10-4

Introduction

This introduction presents an overview of the capabilities and features of TRANSCAL. The organization and use of this manual are described and notational conventions explained.

About TRANSCAL

In the generation and acquisition of underwater acoustic signals, various transducers may be used to provide the interface between the physical pressure fluctuations and the electrical analog of these fluctuations. These transducers include devices which function as sound projectors, hydrophones, or both. Calibration of the transducers is required to enable the correct interpretation of a received signal, or to ensure the desired result in the case of a projected signal.

Calibration of hydrophones involves the measurement of the receiving response and the directional response patterns. The measurement of the receiving response of a hydrophone is the measurement of its free-field voltage sensitivity by comparison to the sensitivity of a known standard hydrophone, or by using reciprocity methods.

Calibration of projectors involves the measurement of the transmitting voltage response or the transmitting current response, the admittance or the impedance and the directional response patterns. The transmitting voltage (or current) response is the ratio of the sound pressure apparent at a distance of one meter in a specified direction from the effective acoustic center of the transducer to the voltage applied across (or the current flowing into) the electrical input terminals. Electrical admittance is the measure of the electrical ratio current/voltage. Electrical impedance is the measure of the ratio voltage/current.

DREA has two facilities for transducer calibrations: the DREA Barge — Acoustic Calibration Facility on Bedford Basin and the DREA anechoic tank. Using these facilities, several calibration procedures are possible:

(1) Transmitting response using swept sine, pulse or CW.

(2) Receiving response using swept sine, pulse or CW.

(3) Directional response.

(4) Receiving response using pseudo-random noise.

(5) Reciprocity.

(6) Receiving response for an array using swept sine, pulse or CW.

(7) Admittance measurement.

(8) Impedance measurement.

The TRANSCAL software controls the calibration procedure, acquires and processes the received data, and presents the results. The current version of TRANSCAL implements procedures 1, 2, 3, 5, 7 and 8 above. In addition, admittance and impedance measurements are incorporated into procedures 1.

Special features

TRANSCAL includes these features:

- A flexible data acquisition environment, including user-selectable pulse width and sampling delay.
- The ability to hold at any frequency, modify settings and observe results, then proceed.

- The ability to switch between pulse and CW modes on-the-fly.
- A variety of dataset presentation options for each procedure, including transmitting voltage response (TVR), transmitting current response (TIR), admittance, and impedance.
- User-defined frequency range.
- Autogain of acquired signals, with a dynamic range of 150 dB.
- Plotting of formatted results directly from within TRANSCAL.
- Data storage to disk for later analysis and presentation.

System requirements

To use TRANSCAL, you need the following hardware and software:

- A Macintosh Quadra 900 computer with 20 MBytes RAM and 200 MBytes disk space.
- National Instruments NuBus boards NB-A2000, NB-DMA-2800, and NB-TIO-10.
- Printer.
- Real Time Systems Programmable Amplifier Model RTS 3510B .
- Krohn-Hite dual filter Model 3958.
- Wavetek 50 MHz Synthesized Arbitrary Waveform Generator Model 296.
- Instruments Inc. Voltage and Current Sensor Model VIT-13.
- Power amplifier .
- Macintosh® system software version 7.0 or later.
- National Instruments LabVIEW® software version 3.1 or later.
- TRANSCAL software.

About this manual

This manual contains instructions for configuring and operating the TRANSCAL software. This section describes the scope and organization of this manual, and the conventions and nomenclature used in developing it.

This manual is intended for the technicians and technologists who are responsible for installing and operating the TRANSCAL system. You should be familiar with Macintosh® computer operations and general underwater acoustic research concepts. However, it is not necessary to be an acoustics signal acquisition and processing expert; Part 1 of this guide provides conceptual information you will need to use TRANSCAL.

Before using TRANSCAL, you should know how to use the mouse and locate files using directory dialog boxes. If you are unfamiliar with the Macintosh user interface or need more detailed information regarding these procedures, please refer to your Macintosh user's guide.

Organization of this manual

This manual begins with basic concepts in Part 1 and proceeds to explicit instructions in Part 2.

It is helpful to understand data acquisition concepts in order to configure the system correctly. To learn these basics, read the chapters in Part 1. If you are already familiar with data acquisition, you may decide to move quickly to Part 2.

Part 2 describes how you install and configure the data acquisition and transmission hardware and then operate the software to achieve the objectives of a specific calibration. The sequence of this process is summarized here:

- Install the hardware as described in Chapter 3.
- Install the software as described in Chapter 4.
- Perform initial setup for a calibration or series of calibrations as described in Chapter 5.
- Use the software to carry out the calibration procedures following the instructions in Chapters 6 to 10.

Conventions used in this manual

The following conventions are used in this guide:

Terms that appear in *italic* type are defined in the paragraph in which they appear. The glossary also defines other terms that are related to your use of the TRANSCAL software.

◆ **Note** Text set off in this manner presents sidelights or interesting points of information. ◆

Δ **Important** Text set off in this manner—with the word *Important*—presents important information or instructions. Δ

Associated documents

You might also find it useful to refer to *LabVIEW for Macintosh User Manual* for a complete description of the LabVIEW software package.

Part 1 Concepts

1 Data Acquisition

Because TRANSCAL is essentially a data collection and data transmission system, it is helpful to have an understanding of data acquisition fundamentals prior to using the TRANSCAL software. This chapter presents a very brief overview of the relevant aspects of a data collection and transmission. The hardware information in this section has been taken from the National Instruments "Data Acquisition Tutorial" in the 1994 National Instruments products catalog. Users should refer to this or other references for more information.

Obtaining proper results from a data acquisition (DAQ) system depends on each of the elements of the system. Figure 1-1 shows an example of a typical data acquisition system.

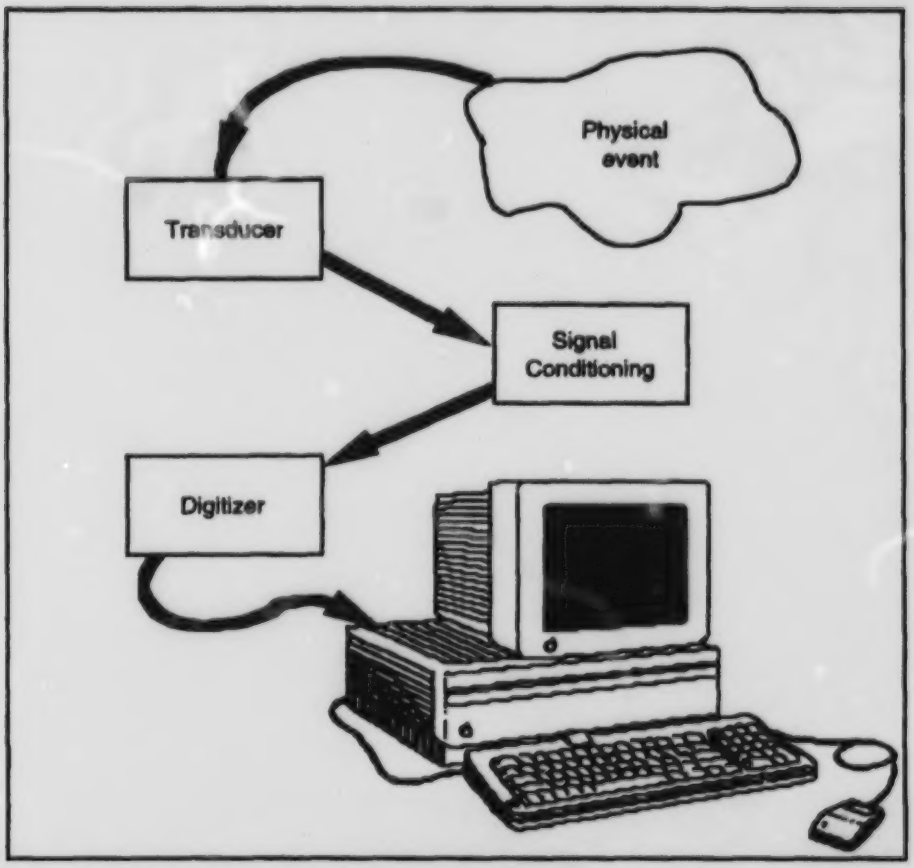

Figure 1-1 A typical data acquisition system

Transducers

Transducers sense physical phenomena and provide electrical signals that the DAQ hardware can accept. The electrical signals produced are proportional to the physical parameters they are monitoring. For TRANSCAL, the data acquisition transducer is a hydrophone.

Signal conditioning

The electrical signals generated by the transducers must be converted into a form that the DAQ board can accept. Signal conditioning can be used to amplify low-level signals, and then isolate and filter them for more accurate and safe measurements.

Amplification

The most common type of conversion is amplification. For the highest possible accuracy, the signal should be amplified so that the maximum voltage swing equals the maximum input range of the analog to digital convertor (ADC).

Isolation

Another common application for signal conditioning is the isolation of transducer signals from the computer for safety reasons. The system being monitored may contain high-voltage transients that could damage the computer.

Filtering

A filter is used to remove unwanted signals from the signal being measured. Slowly varying or DC-class signals might need a low pass noise filter to remove higher frequency signals that can reduce the accuracy of the measurement. AC-class signals, such as sound, require a type of filter known as an antialiasing filter. Like the noise filter the antialiasing filter is a low-pass filter; however, it has a very steep cutoff rate. This ensures that it almost completely removes all frequencies of the signal that are higher than the input bandwidth of the DAQ board. If the signals were not removed, they would erroneously appear as signals within the input bandwidth of the board. Boards designed specifically for dynamic signal measurement typically have antialiasing filters for the board bandwidth built into them. For systems such as TRANSCAL, where the bandwidth of interest is typically lower than the capability of the board, additional antialiasing filtering is required to further reduce the bandwidth of the incoming signal.

Data acquisition hardware

Analog inputs

Single-ended inputs are all referenced to a common ground point. These inputs are typically used when the input signals are high level (greater than 1 V), the leads from the signal source from the analog input hardware are short (less than 5m), and all input signals share a common ground reference. If the signals do not meet these criteria, you should use differential inputs. With differential inputs, each input has its own ground reference. Noise errors are reduced because the common-mode noise picked up by the leads is cancelled out. The NB-A2000 board used in TRANSCAL uses single-ended inputs.

Sampling rate determines how often conversions can take place. A faster sampling rate acquires more points in a given time and can therefore often form a better representation of the original signal. For example, audio signals converted to electrical signals by a microphone commonly have frequency components up to 20 kHz. To properly digitize this signal for analysis, the Nyquist sampling theorem tells us that we must sample at more than twice the rate of the maximum frequency component we want to detect. So, a board with a sampling rate greater than 40 kiloSamples per second (kS/s) is needed to properly acquire this signal. The NB-A2000 board has a maximum sampling rate of 1 megasamples per second.

A better way of stating the above would be to say the sampling rate should be at least twice the rate of the maximum frequency component present. Typically, we would insert an antialiasing filter to ensure that the maximum frequency component present is also the maximum we want to detect. However, filters are not perfect—there is some rolloff, and some higher frequency components will be present. Therefore, a better general guideline would be to use a sampling frequency which is five to ten times higher than the cutoff frequency of the antialiasing filter. Lower sampling rates should only be used when there is a thorough understanding of both the signal being measured and the data collection system.

Multiplexing is a common technique for measuring several signals with a single ADC. The ADC samples one channel, switches to the next channel, samples it, switches to the next channel, and so on. Because the ADC is sampling many channels instead of one, the effective rate of each individual channel is inversely proportional to the number of channels sampled. You can often use external analog multiplexers to increase the number of channels a board can measure. For example, with the AMUX-64T analog multiplexer, you can measure up to 256 signals with a single board. The sampling rate is reduced proportionately by this additional external multiplexing. In TRANSCAL, four channels are multiplexed, giving a maximum sample rate of 250 kHz per channel. Track-and-hold circuitry is used to ensure simultaneous sampling.

Resolution is the number of bits that the ADC uses to represent the analog signal. The higher the resolution, the higher the number of divisions the range is broken into, and therefore, the smaller the detectable voltage change. By using 12 bits of resolution, the number of digital codes to represent the full analog signal range from the ADC is 4,096. The TRANSCAL system has 12-bit resolution.

Range refers to the minimum and maximum voltage levels that the ADC can quantize. The multifunction DAQ boards, such as the NB-MIO-16X, offer selectable ranges so the board is configurable to handle a variety of different voltage levels. With this flexibility, you can match the signal range to the range of the ADC to take advantage of the resolution available to accurately measure the signal. Range of the TRANSCAL system is fixed at ±5 V.

The range, resolution, and gain available on a DAQ board determine the smallest detectable change in voltage. This change in voltage represents 1 least significant bit (LSB) of the digital value, and is often called the code width. The code width is found by dividing the voltage range by the gain times two raised to the order of bits in the resolution. For example, the MIO-16X has a selectable range of 0 to 10 or -10 to 10 V and selectable gain of 1, 2, 4, or 8. With a voltage range of 0 to 10 V, and a gain of 1, the ideal code width is:

$$10\ V / 1 \times 2^{16} = 153\ \mu V$$

Therefore, the theoretical resolution of one bit in the digitized value is 153 μV.

Digital I/O

Digital I/O (DIO) interfaces are often used on DAQ systems to control processes, generate patterns for testing, and communicate with peripheral equipment. A common application is to transfer data between a computer and equipment such as data loggers, data processors, and printers. Because this equipment usually transfers data in one byte (8-bit) increments, the digital lines on a plug-in digital I/O board are arranged in groups of eight. The number of channels, data rate, and handshaking capabilities are all important specifications that should be understood and matched to the application.

Timing I/O

Counter/timer circuitry is useful for many applications, including counting the occurrences of a digital event, digital pulse timing, and generating square waves and pulses. You can implement all of these applications using three counter/timer signals—gate, source, and output. The gate is a digital input that is used to enable or disable the function of the counter. The source is a digital input that causes the counter to increment each time it toggles, and therefore provides the timebase for the operation of the counter. Finally, the output generates digital square waves and pulses at the output line. Digital timing outputs are used in TRANSCAL to control the waveform generation timing and data acquisition.

Data acquisition triggering

The event that initiates data acquisition is called a *trigger*. This event can be a physical event, for example a manual button press or a unique set of data values, or a timing event, for example the actual time matches a scheduled time to start data collection. While in fact all data acquisition occurs in response to some type of trigger, it is common to speak of data acquisition in terms of three types—manual, triggered and scheduled. Manual data acquisition would be the example above of the manual button press. This is often referred to as a manual trigger. Triggered data acquisition typically refers to the case where a system is set to acquire data (armed) upon the occurrence of some unique circumstance, for example a signal exceeds some preset threshold. Scheduled data acquisition refers to the case where a user has set some time in the future to be the instant when data collection commences.

Often it is useful or interesting to have some knowledge of events which precede or lead up to a trigger. Because one typically cannot predict a trigger, the only way to obtain this knowledge is by continuously collecting data in anticipation of a trigger, then save some sensible amount of this pre-trigger data upon commencement of triggered data collection. Naturally, if the pre-trigger data were simply collected and saved, at some point the system's capacity to store data would be exceeded. To overcome this problem, a fixed amount of system memory is allocated for pre-trigger data collection. The oldest data is constantly discarded as new data is collected, and the desired amount of pre-trigger data is saved upon receipt of a trigger. This mode of data collection is called, appropriately, *pre-triggered data acquisition*.

Similarly, it may be desirable to ignore some data following the receipt of a trigger. This may be the case, for example, if the trigger event is followed by a long pause prior to the development of an interesting signal. One would not wish to consume valuable data collection space by acquiring data during the long pause after the trigger. Hence, a delay after the trigger, or post-trigger, is specified during which no data is collected. Following the passage of the post-trigger delay time, data collection commences normally. This mode of data collection is called *post-triggered data acquisition*.

◆ **Note** It is important to understand the above definitions of pre- and post-trigger as they are used in the context of the TRANSCAL system. This is because, to further confuse matters, they are sometimes used in the opposite (semantically correct) sense. That is, pre-triggered data acquisition refers to the situation where a trigger occurs at some time prior to data collection beginning, and post-triggered refers to the situation where a trigger occurs within the block of collected data, i.e. post-beginning-of-data-collection. ◆

2 Transducer Calibration

Overview

In practical usage of the TRANSCAL system, a variety of calibrations are conducted on a transducer or set of transducers. These calibrations typically involve the operation of several available calibration procedures. To simplify the coordination of these activities, the procedures have been grouped within one master program, TRANSCAL. This chapter briefly describes the available calibration procedures within TRANSCAL.

Hydrophone calibration using substitution method

This procedure is used to determine the absolute receiving sensitivity of a hydrophone with respect to a reference standard. A reference hydrophone, with known receiving sensitivity, is placed in the water near a projector. Tone burst or CW signals, swept in frequency across a user-defined frequency band, are generated by the signal generator and are applied to the power amplifier driving the projector. The voltage output of the hydrophone is digitized and stored in the computer. The hydrophone to be calibrated, the "unknown", is then placed in the water near the projector. The same series of tone burst or CW signals are applied to the projector, and the voltage output of the unknown hydrophone is digitized. The receiving sensitivity of the unknown hydrophone can then be calculated using the measured sensitivity of both hydrophones and the known receiving sensitivity of the reference.

Projector calibration using tone burst and/or CW

This procedure is used to determine the Transmitting Voltage Response (TVR) and/or Transmitting Current Response (TIR) of a projector. The projector to be calibrated is placed in the water near a hydrophone of known sensitivity. Tone burst or CW signals, swept in frequency across a user-defined frequency band, are generated by the signal generator and are applied to the power amplifier driving the projector. The voltage and current applied to the projector and the voltage output of the hydrophone are digitized and processed by the computer. The TVR and/or TIR of the projector are determined from the measured drive current and voltage, and from the voltage output of the hydrophone.

Hydrophone calibration using pseudo-random noise

This procedure is used to determine the receiving sensitivity of a hydrophone with respect to a reference standard. This calibration procedure is identical to hydrophone calibration using tone bursts and/or CW signals, except that the sound source is a pseudo-random noise sequence, rather than tone bursts or CW. This calibration task is used primarily at the acoustic tank when low frequency (less than 2 kHz) calibrations are performed.

Measurement of transducer directivity patterns

This procedure is used to determine the relative directional receiving sensitivity or transmitting response of a transducer. The transducer under test, a hydrophone or projector, is placed in the water on a rotatable station near a projector or hydrophone, respectively. An electric motor is used to rotate the unit under test through 360 degrees of arc. A digital timing trigger is sent by the rotating station to the computer every 0.1 degrees. When triggered, the computer causes a number of tone bursts, at user-definable frequencies, to be applied to the projector. The voltage output of the hydrophone is digitized and stored in the computer. The data are processed to form the directivity pattern and directivity index for the unit under test at the specified frequencies.

Absolute calibration using the reciprocity method

This procedure is used to determine the absolute receiving sensitivity of a hydrophone. The method requires a hydrophone, a projector, and a reciprocal transducer, i.e., a transducer that can function as both a projector and a hydrophone. Any one of these transducers can be the unknown, however, the method is most frequently used to calibrate a hydrophone for later use as a "standard". The hydrophone is placed in the water near the projector. Tone burst or CW signals, swept in frequency across a user-defined frequency band, are generated by the signal generator and are applied to the power amplifier driving the projector. The voltage output of the hydrophone is digitized and stored in the computer. The process is repeated with the reciprocal transducer in place of the hydrophone, and then with the reciprocal transducer in place of the projector. The receiving sensitivity of the unknown can then be calculated using these measured sensitivities.

Measurement of transducer admittance and impedance

This procedure is used to determine the electrical admittance and impedance of a transducer. Tone burst or CW signals, swept in frequency across a user-defined frequency band, are generated by the signal generator and are applied to the power amplifier driving the projector. The voltage and current applied to the transducer are digitized and processed to form the admittance and impedance of the transducer.

Part 2 Procedures

3 Hardware Installation and Wiring

NuBus board installation

TRANSCAL accomplishes analog I/O, digital I/O, DMA data transfer and peripheral control using standard National Instruments NuBus boards. Boards should be installed following the directions in the appropriate manuals. Be sure to observe proper handling procedures for the prevention of board damage due to electrostatic discharge.

The following National Instruments boards are required:

- NB-A2000 for analog signal capture,
- NB-DMA-2800 for internal DMA data transfer and IEEE-488 peripheral communication, and
- NB-TIO-10 for digital timing I/O.

Boards must be installed in specific NuBus slots. The actual locations of the boards may be confirmed using the National Instruments "NI-DAQ" utility. NI-DAQ is a control panel, and is typically activated by dragging down the Apple Menu to Control Panels, and selecting NI-DAQ. The NuBus is scanned for boards, and a window is presented with a listing of the slots and boards. Additional information can be obtained by clicking on the appropriate button. Figure 3-1 shows the NI-DAQ control panel with the required board configuration.

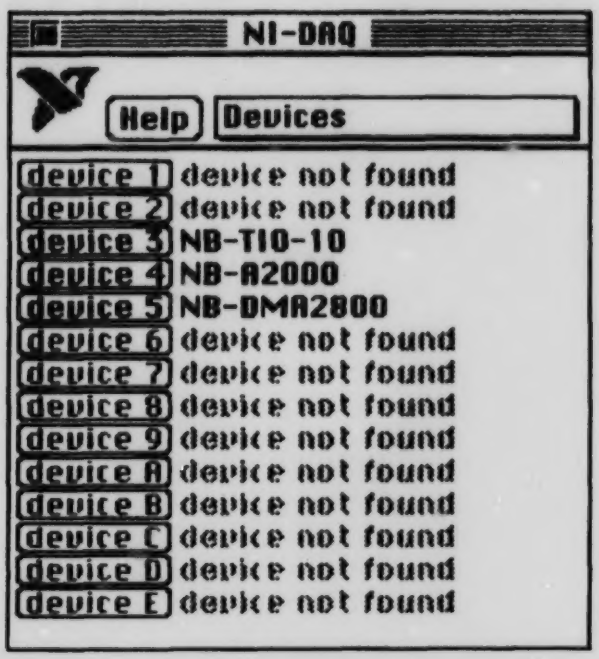

Figure 3-1 NI-DAQ control panel

Peripheral configuration

Figure 3-2 shows a typical setup for the peripherals which comprise the TRANSCAL system. The particulars of the components may change, provided the functional requirements are met.

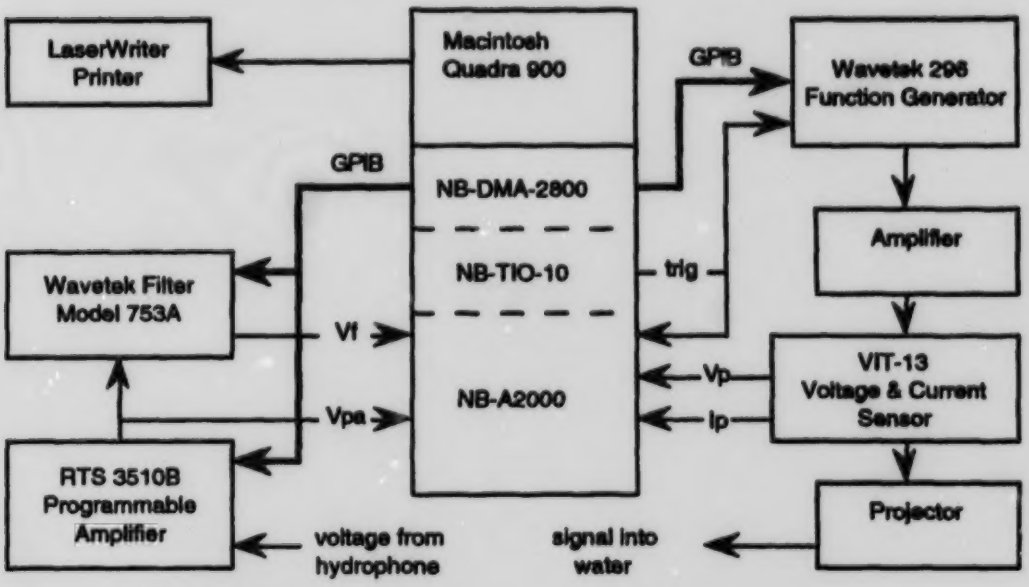

Figure 3-2 TRANSCAL peripherals

The NB-A2000 cards are fitted with BNC coax connectors. Connections to the TIO-10 board is via an interface box or cable harness to BNC coax connectors. Figure 3.3 shows the NuBus board connections to the Macintosh Quadra 900.

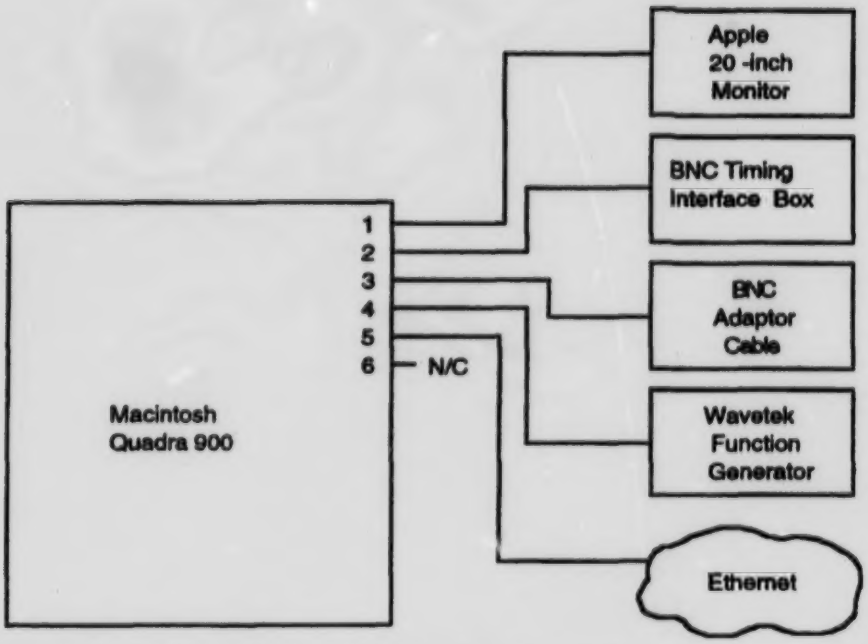

Figure 3-3 Macintosh Quadra 900 NuBus connections

Wiring

Table 3.1 shows the interconnection between the NB-A2000 and the other devices.

Table 3-1 NB-A2000 connections

Pin	NB-A2000 Signal Name	TRANSCAL Signal Name	Destination	Conductor
1	ACH0	Projector Voltage	VIT-13 Voltage	RG-58 coax
2	ACH1	Projector Current	VIT-13 Current	RG-58 coax
3	ACH2	Preamp out	RTS3510B SIGNAL OUT	RG-58 coax
4	ACH3	Filter out	K-H 3988 Ch2 OUTPUT	RG-58 coax

5	DTRIG	Sample Trigger	NB-TIO-10 Timing Interface Box Ch 28	RG-58 coax
6	ATRIG		N/C	
7			N/C	

Table 3.2 shows the interconnection between the NB-TIO-10 interface and the other devices. All connections are referenced to the NB-TIO-10 interface connector.

Table 3-2 NB-TIO-10 connections

Pin	NB-TIO-10 Signal Name	TRANSCAL Signal Name	Destination	Conductor
6	OUT2			RG-58 coax
28	OUT10	TRIG IN	Wavetek 296 TRIG IN	RG-58 coax
33	GND	GND	Shaft encoder	
35	A0	ZERO	Shaft encoder	
36	A1	CW	Shaft encoder	
37	A2	CCW	Shaft encoder	
38	A3			

Table 3.3 shows the interconnection between the RTS 3510B programmable amplifier and the other devices. All connections are referenced to the RTS 3510B.

Table 3-3 RTS 3510B connections

Pin	RTS 3510B Signal Name	TRANSCAL Signal Name	Destination	Conductor
	MUX INPUT 0	Vstandard	Standard hydrophone	coax
	MUX INPUT 2	Vunknown	Unknown hydrophone	coax
	FILTER OUT		IN (+)	coax
	SIGNAL OUT	Preamp Out	1. KH 3988 CH1+INPUT 2. NB-A2000 ACH2	coax

Table 3.4 shows the interconnection between the Krohn-Hite Model 3988 filter and the other devices. All connections are referenced to the K-H 3988.

Table 3-4 Krohn-Hite 3988 connections

Pin	Krohn-Hite 3988 Signal Name	TRANSCAL Signal Name	Destination	Conductor
	GPIB		1. Wavetek 296 2. RTS 3510B	IEEE-488 cable
	Ch1+ INPUT	Preamp Out	RTS 3510B SIGNAL OUT	coax
	Ch2+ INPUT		Ch1+ OUTPUT	coax
	Ch2 OUTPUT	Filter Out	NB-A2000 ACH3	coax

Table 3-5 Wavetek 296 connections

Pin	Wavetek 296 Signal Name	TRANSCAL Signal Name	Destination	Conductor
	TRIG IN	TRIG IN	1. NB-TIO-10 pin 28 2. NB-A2000 DTRIG	coax
	MAIN OUT	Source Out	MCINTOSH Power Amp RINPUT (typ)	coax
	Z-AXIS OUT		'scope EXT Z AXIS IN	optional

Switch settings

The RTS 3510B Programmable Amplifier switches should be set as follows:

- DIFF/OFF set to the OFF position
- AUTO DC/OFF set to the ON (AUTO DC) position
- IEEE 488 switch up, i.e. set to IEEE 488 remote operation
- POWER switch up, i.e. power on

The GPIB address for the RTS 3510B is set internally to address = 2. Refer to the RTS 3510B user manual for instructions.

The Wavetek Model 753A Brickwall Filter GPIB address is set externally to address = 3, using the DIP switch located on the rear panel.

The Wavetek Model 296 Function Generator is set to GPIB address = 1, using the front panel controls or the mouse. Refer to the user manual for instructions.

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4 Software Installation

Installation of the TRANSCAL software is possible from diskettes Iomega Jaz drive, or tape backup system. Typically, installation is done from a Jaz drive cartridge.

Required system configuration

TRANSCAL for the 680x0-based Macintosh requires a math coprocessor. The minimum capability Macintosh recommended, for acceptable performance, is the Macintosh Quadra 900.
LabVIEW 3.1 requires a minimum of 5 MB of available RAM, in addition to the RAM requirements for your system software and any other applications that you may want to run simultaneously. TRANSCAL requires an additional 9 MB of RAM, which includes RAM for captured data storage. The TRANSCAL application itself requires about 7 MB. We strongly recommend that you have at least 20 MB of RAM. A typical configuration would be 24 MB of system RAM, with 20 MB allocated to LabVIEW for running TRANSCAL.

Organization of the TRANSCAL system

After installation, the TRANSCAL system will be organized as shown in Figure 4-1.

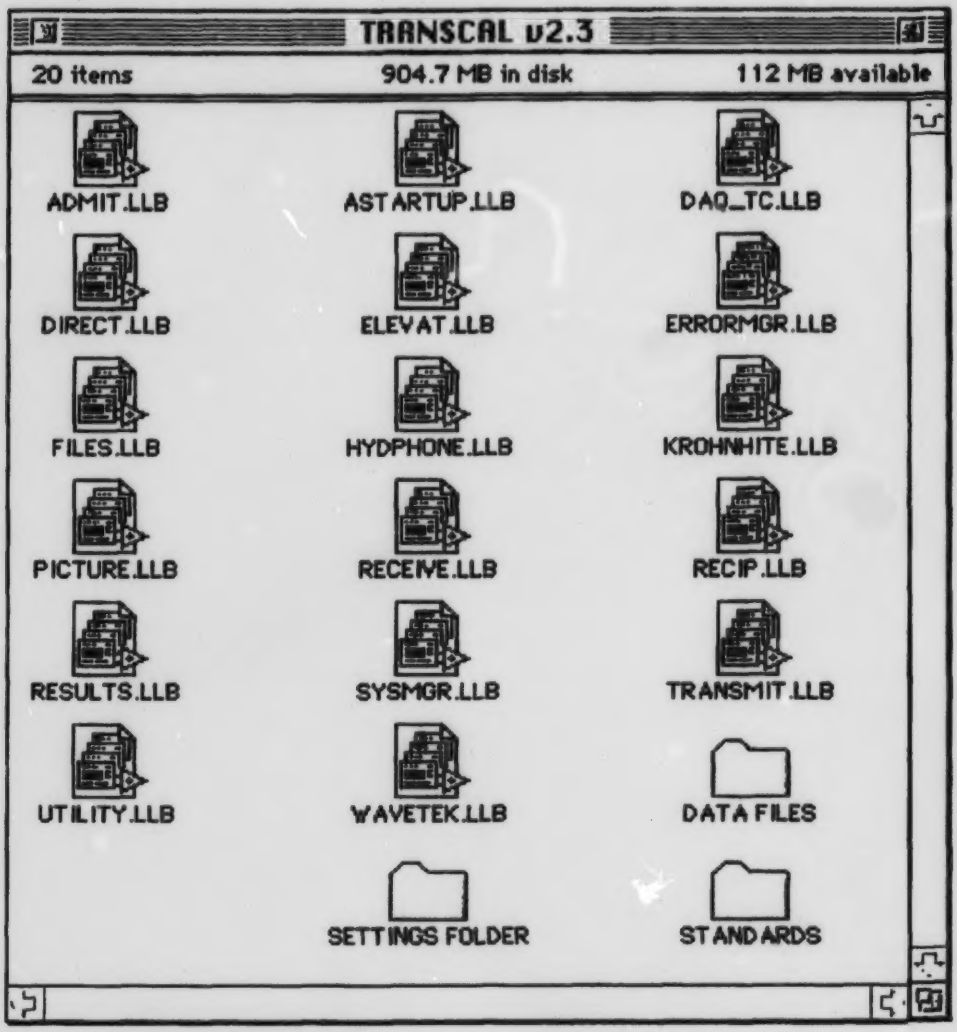

Figure 4-1 TRANSCAL VI organization

Installation procedure

Δ **Important** You need 5 MB of free disk storage space to install the TRANSCAL application. Running TRANSCAL demands free disk space to store captured data files. A minimum of 20 MB of free disk space is recommended for running TRANSCAL. Δ

1. If you are installing from floppy disks, there should be 6 diskettes in total. The TRANSCAL VIs are organized into libraries consistent with Figure 4-1. The contents of Disk 1 should be dragged (copied) from the floppy into a folder named simply *TRANSCAL vN.n*, as in Figure 4-1.

   ◆ **Note** The VIs on the floppies are not compressed. Individual libraries or VIs may be copied as required, for example if a single VI has become corrupted or changed. ◆

   Continue copying VIs from the floppies into the TRANSCAL folder.

2. If you are installing from a Jaz removable cartridge, the procedure will be simpler. Drag (copy) the TRANSCAL VIs folder to your hard drive. All enclosed folders and files will be copied to the appropriate locations. For tape backup systems, follow the directions provided with the drive.

After you have completely installed TRANSCAL , it is ready to run.

5 Using TRANSCAL

Starting TRANSCAL

Locate the TRANSCAL Startup alias icon. Typically, this will be found on the desktop. Figure 5-1 shows the icon in the top right corner of the screen, next to the hard drive icon. The TRANSCAL application will startup, and you will see the front panel as in Figure 5-2.

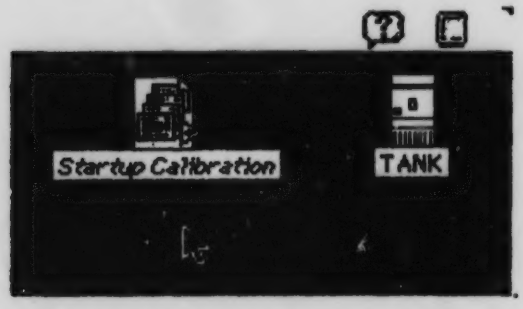

Figure 5-1 TRANSCAL startup icon

If the TRANSCAL Startup icon is not found, locate the ASTARTUP.LLB VI library in the TRANSCAL folder, and use the Finder File/Make Alias function to create a new startup icon. Rename the alias "Startup Calibration".

To start the TRANSCAL application, click on the Run arrow. TRANSCAL is now running and ready for operation, and should look like Figure 5-2.

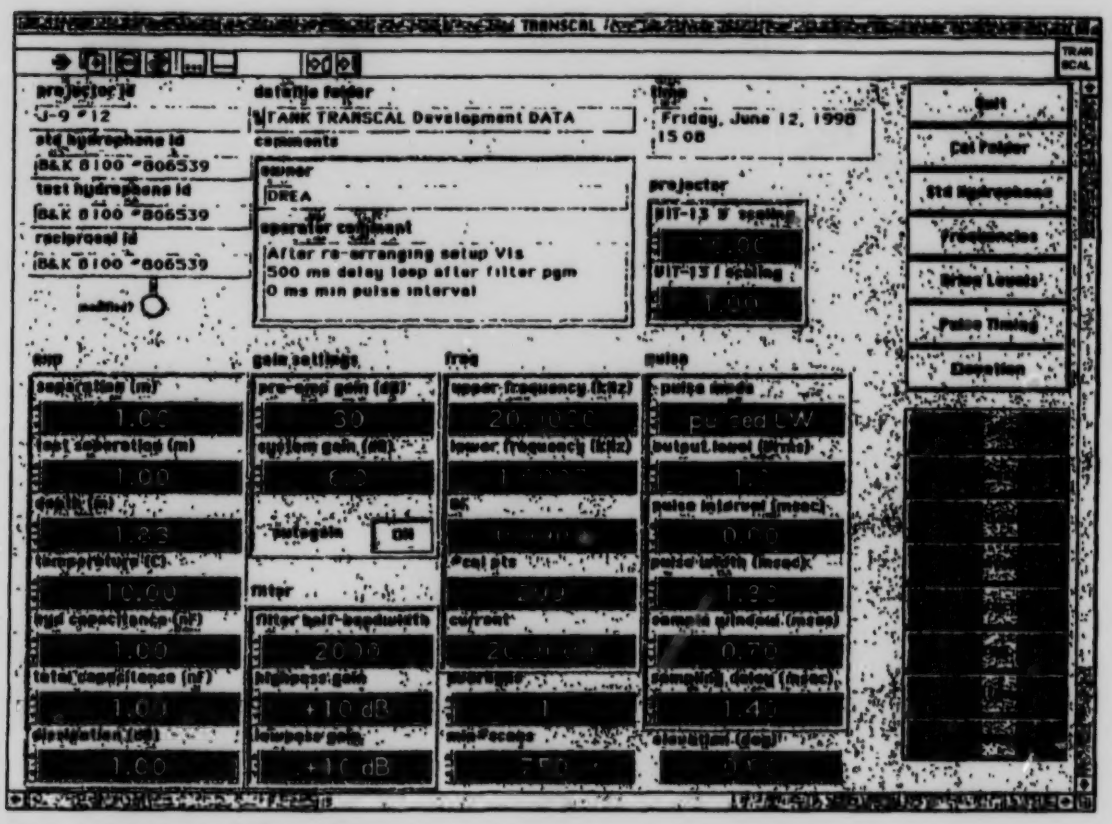

Figure 5-2 TRANSCAL front panel

Using TRANSCAL primarily involves running the front panels for the various calibration procedures. Some settings are made directly on these front panels. There are, however, a number of settings which will affect all calibration procedures. These settings can be made by using the TRANSCAL main panel. The subsections which follow detail the individual controls and indicators.

Calibration procedure front panels are activated by pressing the labelled buttons on the TRANSCAL front panel. To simplify future additions and enhancements, calibration procedures are described in the dedicated chapters which follow. When you are finished with a calibration front panel, you return to the TRANSCAL front panel. To quit the TRANSCAL application, press the Quit button.

Setting the calibration folder

The files created by TRANSCAL will be stored in the folder which you name. You select the storage folder using a standard LabVIEW dialog box. To select the file folder for logging, click on the Cal Folder button below the Quit button shown in Figure 5-2. You will be presented with a dialog for file selection, seen in Figure 5-3.

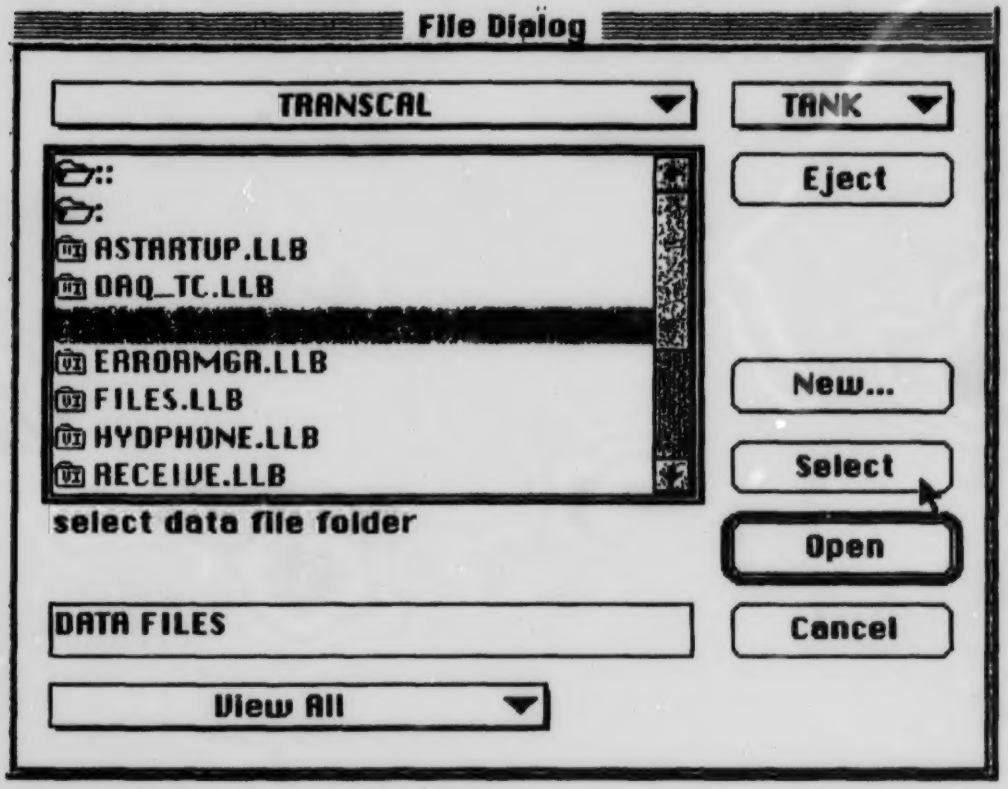

Figure 5-3 Select logging folder dialog

You must select the folder and then click select as shown to choose the desired folder. If you "open" the folder, as you might be used to doing, you cannot then "select" the folder. You will be forced to "back up" one layer in the hierarchy and "select." The confusion arises the next time you access this dialog. As it should, the dialog opens to the currently selected folder, seen in Figure 5-4. However, you cannot select from the currently selected folder; unless you select the folder icon with the double-colon (::). You must back up to the previous layer. Clear as mud?

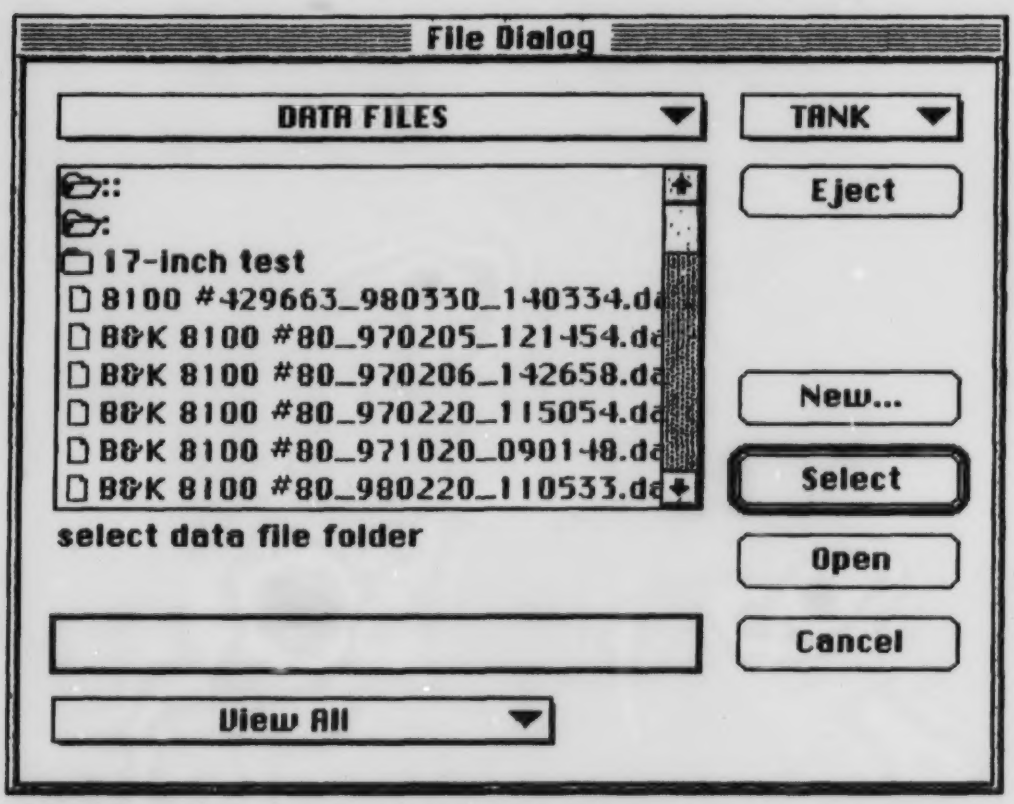

Figure 5-4 Select logging folder dialog with folder open

Selecting the standard hydrophone calibration

You have the option of selecting alternate hydrophone calibration curves. During startup of TRANSCAL, a front panel (Figure 5-5) appears showing the calibration curve for the default standard hydrophone. Pressing *Done* confirms the default. This same panel can be accessed after startup by pressing the Std Hydrophone button from the TRANSCAL front panel.

To Select a different calibration standard, press the *Select* button. Pressing the Select button opens another panel, shown in Figure 5-6. This standard LabVIEW file dialog is used to select a new hydrophone calibration file. Press *OK* to confirm the selection, or press *Cancel* to return without changing the current selection. If after having selected a new calibration curve, you then decide not to use it, pressing *Cancel* on the standard hydrophone selection front panel returns control to the main panel, and no changes are made to the standard hydrophone calibration data.

Figure 5-5 Standard Hydrophone Sensitivity front panel

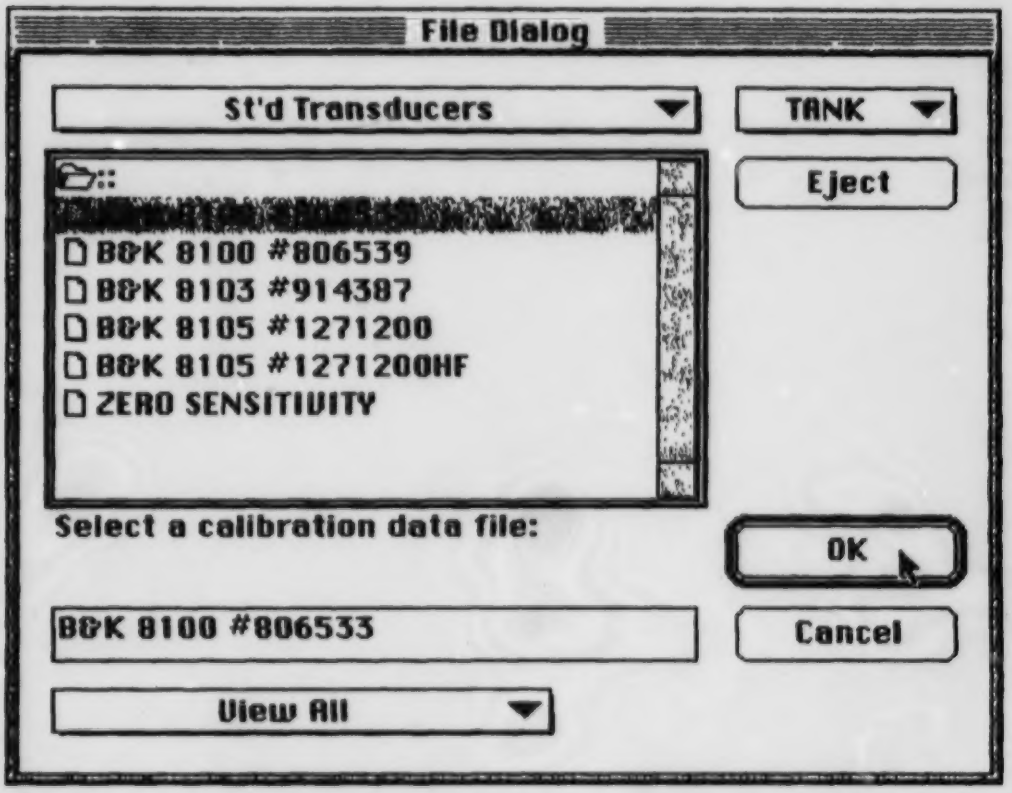

Figure 5-6 Selecting a new standard hydrophone

Selecting the calibration frequency range

The Setup Calibration Frequencies front panel (Figure 5-7) is used to modify the current frequency range and resolution. The area on the left shows the current settings for the frequency range. Pressing the button below this area will return control to the calibration front panel, without changing the current settings.

New values are entered in the area to the right. The frequency decrement (DF) value determines the resolution of the calibration frequencies. The closer the value is to the maximum of 1.0, the closer the next frequency value will be to the previous one, that is a higher or finer resolution. Decreasing the value will result in a larger difference, or coarser resolution. There are a maximum of 1024 data points possible. The value for DF which would result in 1024 data points being created is called *DFMAX*. Creating the maximum number of data points is easy — just press the *USE DFMAX* button. The *# cal* frequencies indicator provides instant feedback on how many sample points would result from your current settings. Typically, lower numbers are used to scan through the range quickly to get a first look at the calibration curve, set drive levels, etc. Later, higher numbers of points are used to increase the resolution of the final calibration.

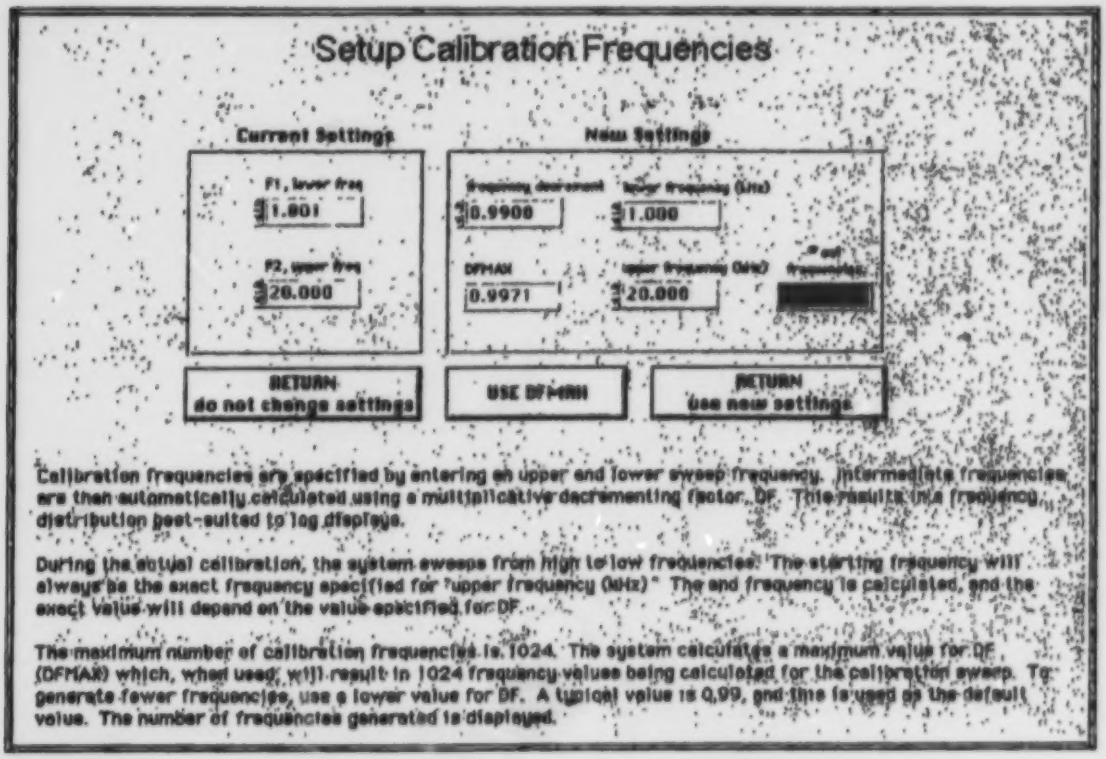
Setup Calibration Frequencies
Current Settings
F1, lower freq
1.801
F2, upper freq
20.000
New Settings
0.9900
1.000
DFMAX
0.9971
20.000
RETURN
do not change settings
USE DFMAX
RETURN
use new settings
Calibration frequencies are specified by entering an upper and lower sweep frequency. Intermediate frequencies are then automatically calculated using a multiplicative decrementing factor, DF. This results in a frequency distribution best-suited to log displays.
During the actual calibration, the system sweeps from high to low frequencies. The starting frequency will always be the exact frequency specified for "upper frequency (kHz)." The end frequency is calculated, and the exact value will depend on the value specified for DF.
The maximum number of calibration frequencies is 1024. The system calculates a maximum value for DF (DFMAX) which, when used, will result in 1024 frequency values being calculated for the calibration sweep. To generate fewer frequencies, use a lower value for DF. A typical value is 0.99, and this is used as the default value. The number of frequencies generated is displayed.

Figure 5-7 Setting the frequency range

Setting the projector drive levels

The *Setup Drive Levels* front panel (Figure 5-8) is used to establish the optimum signal voltage and hydrophone output preamplifier and filter gain setting. This feature is typically used if the system is going to be used with autogain off. The settings made using this panel are communicated to the calibration procedure front panel. Any or all of the graphs can be turned off using the *DISPLAY MODE CONTROLS*.

The *projector voltage (Vrms)* and *projector current (Irms)* graphs plot the values over the current frequency range. The *projector voltage (Vrms)* graph has an additional line shown in red. This is the maximum recommended projector voltage, which you enter using the *max projector volts* control. The red line provides an indication of projector overvoltages.

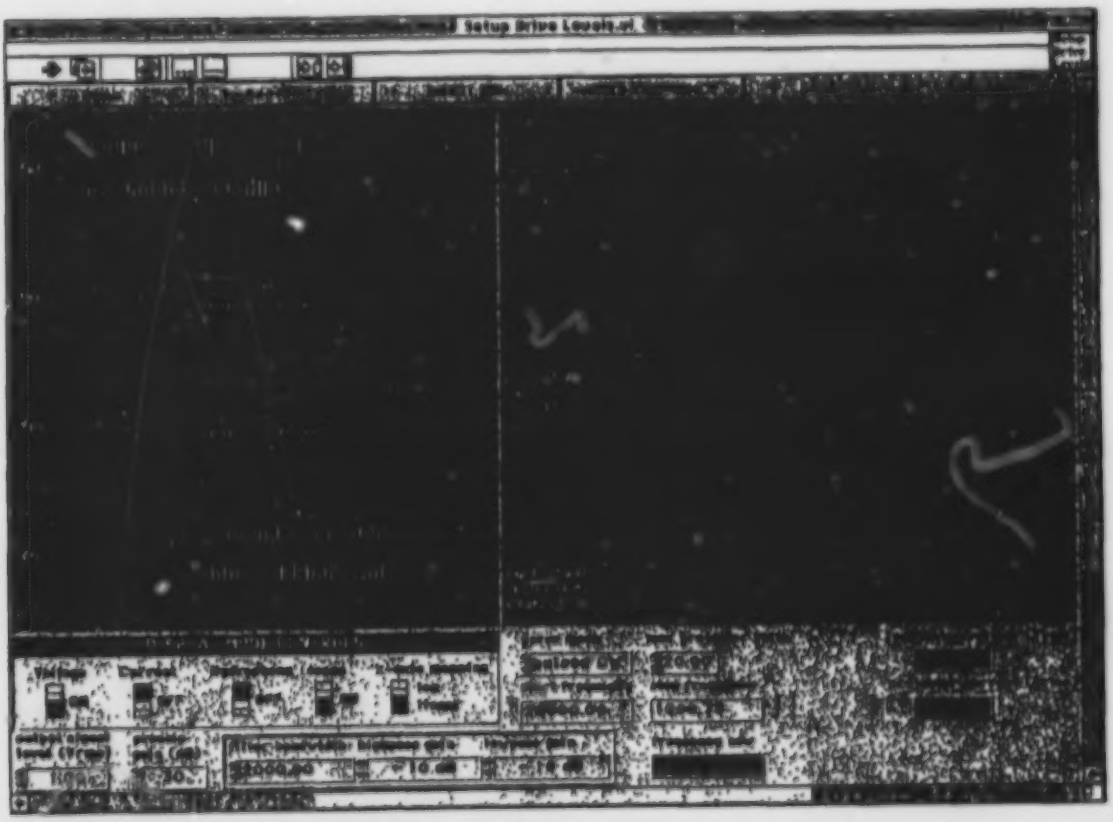

Figure 5-8 Setting the projector drive levels

Setup the pulse timing

The *Setup Pulse Specs* front panel (Figure 5-9) is used to setup the optimum pulse timing parameters for signal generation and data acquisition.

Figure 5-9 Setting the pulse specifications

The *projector current (# samples)* and *filter output (# samples)* graphs plot the number of sample points used to calculate the Discrete Fourier Transform (DFT) of the captured pulse waveform. The DFT is used to calculate the calibration data points. The graphs show the number of samples, calculated automatically by the program. Selecting a longer pulse width will result in a larger number of samples of hydrophone data. Typical values are between 100 and 300 samples, which provide a good compromise between processing speed and accuracy. The plots update at the end of each pass.

You change the pulse parameters using the *pulse specs* controls. The effect of changes to the parameters are seen in the graphs along the left side of the front panel, similar to the transmit response calibration front panel.

PW (msec) is the pulse width in milliseconds. This is the minimum width of the calibration source pulse out of the projector. An integral number of cycles will always be generated, and the entered value specifies a minimum pulse duration. The actual duration is typically longer, and will be the minimum time, greater than the specified value, to generate an integral number of cycles at the current frequency.

TW (msec) is the time window from which the acquired signal is sampled. The program will try to optimize the number of samples taken from within the window, and will always extract integral half-cycles.

The *sampling delay (msec)* control specifies how long the program waits, from the start of the excitation pulse, before the start of the time window, TW. The delay is necessary for the sound to propagate through the water from the projector to the hydrophone, and for the transients to dampen out in the hydrophone.

In addition to the sound pulse which propagates directly from the projector to the hydrophone, there will be reflected sound pulses from the surface of the water, and the sides and bottom of the tank. Typically, the surface reflection is the first and the worst reflection to arrive at the hydrophone. To limit the effects of interference and reverberations from these reflections, the excitation pulse is limited in duration. The ***max pulse width (ms)*** indicator provides a calculation of the expected arrival time of the surface reflection, based on the values you enter for depth and separation. You may still enter any value you wish for pulse width, the value is simply an indication of when to expect interference from a surface reflection. Limiting pulse duration to below this value will ensure the complete pulse arrives at the hydrophone before the wavefront of the surface reflection arrives.

Setup the elevation

Elevation control of a transducer is a planned enhancement to TRANSCAL. An interface to a motion control system has been developed (the hardware does not yet exist). The *Elevation* front panel (Figure 5-10) is used to setup the angle of elevation, and is activated by clicking on the Elevation button.

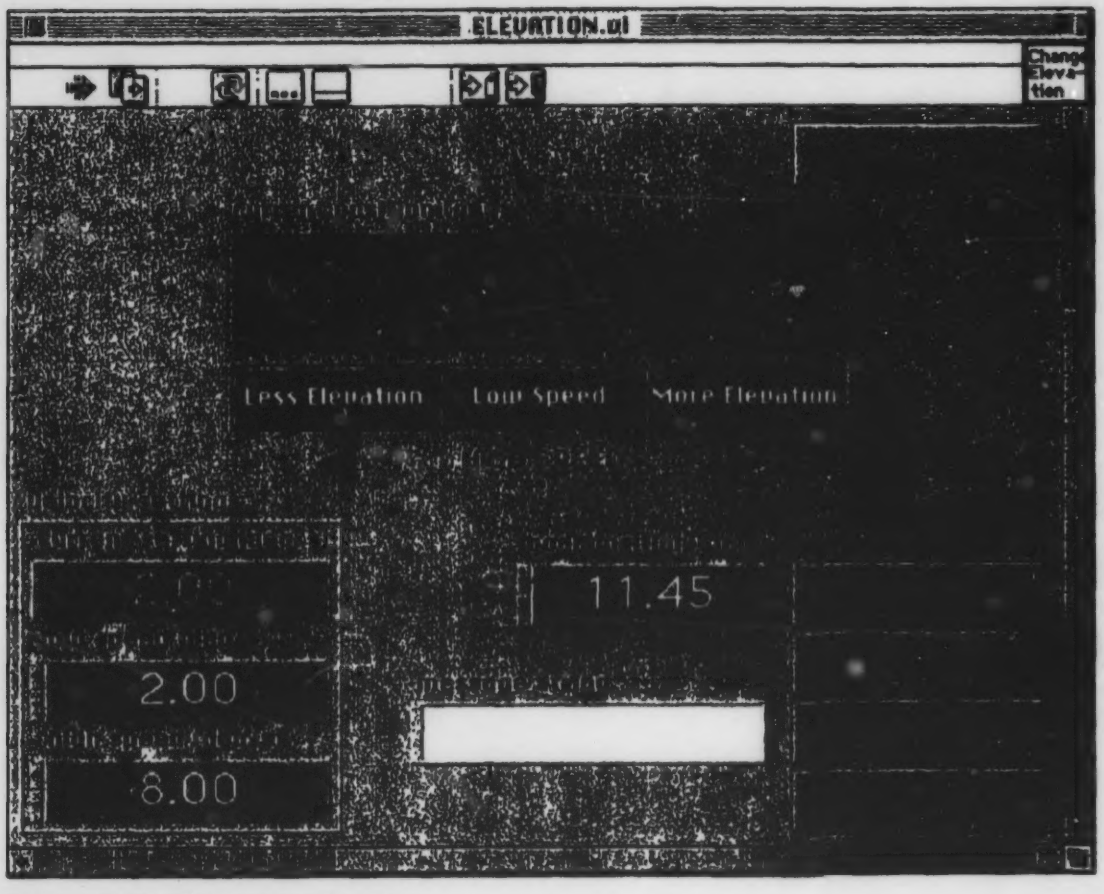

Figure 5-10 Setting the elevation

The *Less Elevation* and *MoreElevation*controls are used to interactively move the elevation mechanism to a desired angle. The current angle is displayed in the *current position (deg)* indicator. Two speeds for movement are possible. Speeds are set using the *low speed (deg/s)* and *high speed (deg/s)* controls. The currently active speed, which is displayed in the *current setting (deg/s)* indicator, is selected by clicking on the *Low Speed/High* Speed control.

It is possible to send the elevation mechanism to a known angle by entering a number in the *goal position (deg)* control, then clicking on the *Go To Position* control button. To send the mechanism to the home position, click on the *Send Home* button. The home position can be reset to any desired location by sending the mechanism to the desired position, then clicking the *Reset Home* button.

Any command message can be sent to the motion control system by typing the message into the *message string* indicator, then clicking the *Send Message* button. To return to the TRANSCAL main panel, click the *Done* button.

Modal Controls

The controls shown in the bottom right of Figure 5-2 redirect control the various calibration modes of TRANSCAL. This section briefly describes the function of the controls. The sections detailing the purpose and operation of the resulting front panels follows later in this chapter.

Transmit Response

This button invokes the transmit response calibration mode, described in Chapter 6.

Receive Response

This button invokes the receive response calibration mode, described in Chapter 7.

Directional

This button is used to direct control to the *Directivity* front panel, used to generate directional response patterns. Directivity calibration is described in Chapter 8.

PRN Receive

This button will be used to direct control to the pseudo-random noise calibration mode. This mode has not yet been implemented.

Reciprocity

This button invokes the reciprocity calibration mode, described in Chapter 9.

Array

This button will be used to direct control to the array calibration mode. This mode has not yet been implemented.

Admittance

This button invokes the standalone admittance/impedance calibration mode, described in Chapter 10.

Impedance

This button also invokes the standalone admittance/impedance calibration mode, described in Chapter 10.

Current Settings

The current settings are shown in a collection of controls and indicators, described below.

projector id

This control is used to enter the identifier string for the projector. The identifier will appear on the plot titles, and is used as a prefix to generate file names for saved data.

std hydrophone id

This control is used to enter the identifier string for the standard hydrophone. The identifier is saved in the stored data files.

test hydrophone id

This control is used to enter the identifier string for the unknown or test hydrophone. The identifier is saved in the stored data files, used to form the graph titles, and becomes the data file prefix.

reciprocal id

This control is used to enter the identifier string for the reciprocal transducer used in a reciprocity calibration.

data file/folder

This indicator shows the current folder and filename to which saved data will be stored. The filename prefix forms the root of the filename. A date and time tag is appended to this prefix to create a unique filename for each file. You change the folder and filename by pressing the select button and using the file dialog to navigate to the new location.

comments

This set of controls is used to enter comments which appear on the output data plots and data files.

time

This is the current date and time.

VIT-13 V scaling

This control is used to enter the voltage scaling factor manually selected on the front panel of the VIT-13 amplifier voltage and current monitor. For example, if the voltage setting is 100mV/V, then the scaling factor is 10.

VIT-13 I scaling

This control is used to enter the current scaling factor manually selected on the front panel of the VIT-13 amplifier voltage and current monitor. For example, if the current setting is 1 V/A, then the scaling factor is 1.

separation (m)

This control is used to enter the separation, in meters, between the projector and the standard hydrophone.

test separation (m)

This control is used to enter the separation, in meters, between the projector and the unknown or test hydrophone.

depth (m)

This control is used to enter the depth, in meters, between the surface and the hydrophone.

temperature (C)

This control is used to enter the water temperature, in degrees Celsius. This value is used to annotate the data plots, and is stored to file with the calibration data.

hyd capacitance (nF)

This control is used to enter the measured capacitance, in nanoFarads, of the unknown hydrophone. This value is required for the calculation of the test hydrophone sensitivity.

total capacitance (nF)

This control is used to enter the measured capacitance, in nanoFarads, of the unknown hydrophone and the test cable. This value is also required for the calculation of the test hydrophone sensitivity.

dissipation

This control is used to enter the measured transducer dissipation. The entered value is not used to generate calibration results, but is saved to the stored data file.

pre-amp gain (dB)

When autogain is turned on, this control shows the starting gain setting for the RTS 3510B programmable amplifier. When autogain is turned off, the control is used to enter manually the gain set on the front panel of the 3510B, to allow the program to include the gain in the calibration.

system gain (dB)

This control allows the user to enter the total gain contributed by other system elements. The value is typically 6 dB to account for the additional pre-amp gain resulting from high impedance output termination. Other gains, for example from additional amplifiers or attenuators get accounted for in this control.

autogain

This control is used to turn autogain on or off. When autogain is on, the system tries to maintain an optimum voltage level at the analog-to-digital convertor input. It does this by adjusting the values for the preamp and filter gain stages.

filter half-bandwidth

Pulsed measurement systems using narrowband filters and short pulses suffer from distortion. A rectangular pulse passed through a bandpass filter will be distorted to only a small extent, if the filter bandwidth is 2/pulse length. For example, a typical pulse length of 0.5 msec will result in an essential bandwidth of 4000 Hz, or a half-bandwidth of 2000 Hz. This control determines the bandpass of the filter. You enter the filter half-bandwidth, which is the frequency separation between the current centre frequency and the lowpass and highpass cutoff frequencies. That is, the total bandwidth is twice the entered value.

◆ **Note** The Krohn-Hite Model 3988 filter is currently being used in its Bessel filter mode. To obtain zero insertion loss at the centre frequency, the low frequency cutoff is 0.1 x centre frequency, and the high frequency cutoff is 10 x centre frequency. The filter half-bandwidth control has no effect. It has been left in for anticipated future use. ◆

highpass gain

This indicator shows the current highpass gain setting for the filter. If autogain is on, the value is updated automatically. If autogain is off, you select the desired value from the available settings for the filter.

lowpass gain

This indicator shows the current lowpass gain setting for the filter. If autogain is on, the value is updated automatically. If autogain is off, you select the desired value from the available settings for the filter.

upper frequency (kHz)

This indicator shows the maximum frequency setting for the calibration run.

lower frequency (kHz)

This indicator shows the minimum frequency setting for the calibration run.

DF

This is the decrementing factor used to calculate the frequency points for the calibration data, where f(n+1) = DF*f(n).

 # cal pts

This indicator shows the number of calibration points in the current calibration. Increasing the decrementing factor raises the number of points, up to a maximum of 1024.

current

This indicator shows the current frequency setting during the calibration run. The indicator is updated as data collection progresses. On the main TRANSCAL panel, the value indicates the starting frequency.

averages

This control is used to enter the number of passes which get averaged to calculate the final calibration curve.

min # scans

During data acquisition, the system calculates the number of minimum number of scans required to capture the specified pulse. This is the data which is displayed in the acquired data graphs. Sometimes, you may want to acquire additional data, say to look at reverberation effects. This control is used to set the minimum number of scans acquired. The actual duration of acquired data gets displayed as the X-axis of the graphs, and will depend on the current sampling frequency. For example, 750 scans at a 250 kHz sampling rate would result in 3 milliseconds of data.

pulse mode

Usually, pulsed sine tones are used, but if CW is required, set it using the *pulse mode* control.

output level (Vrms)

The default output level is 1 volt rms. If this is too large, enter the required level using the ***output level*** control.

pulse interval (msec)

You can specify a delay from the end of one pulse to the beginning of the next. This is usually to allow more time for reverberations to die down. Setting this control is not usually required for a simple calibration, since by the time the calculations are complete and the graphs are updated, the reverberations have already disappeared. It is often used if there are system delays that have to be allowed for. Set the value using the ***pulse interval*** control.

pulse width (msec)

The minimum duration of the source pulse is set using the ***pulse width(msec)*** control. The value entered will be a minimum length. The actual length will depend on the pulse frequency, partial cycles are not generated.

sample window (msec)

The ***sample window (msec)*** control is used to set the width, in milliseconds, of the time window from which the system will extract samples for calculations. If you wish to see the effects of changes to the pulse parameter settings, use the ***Pulse Timing*** button.

sampling delay (msec)

In water, there is a delay while the pulse travels from the projector to the hydrophone. The length of the delay, in milliseconds, is specified in the ***sampling delay (msec)*** control so the system knows where to begin looking for received data.

elevation (deg)

This indicator shows the current angle of the elevation mechanism.

Calibration Data Acquisition

Most calibration data will be collected using the same calibration sequence panel. Since this is a common procedure to all modes, it will be described here. The CAL SEQUENCE panel is shown in Figure 5-11 below. The paragraphs following the figure describe the controls unique to the CAL SEQUENCE panel. Many setup controls from the TRANSCAL main panel are repeated on the CAL SEQUENCE panel. The effect of entering values form either panel is the same, with the exception that values entered on the CAL SEQUENCE panel are not coupled back to the main panel.

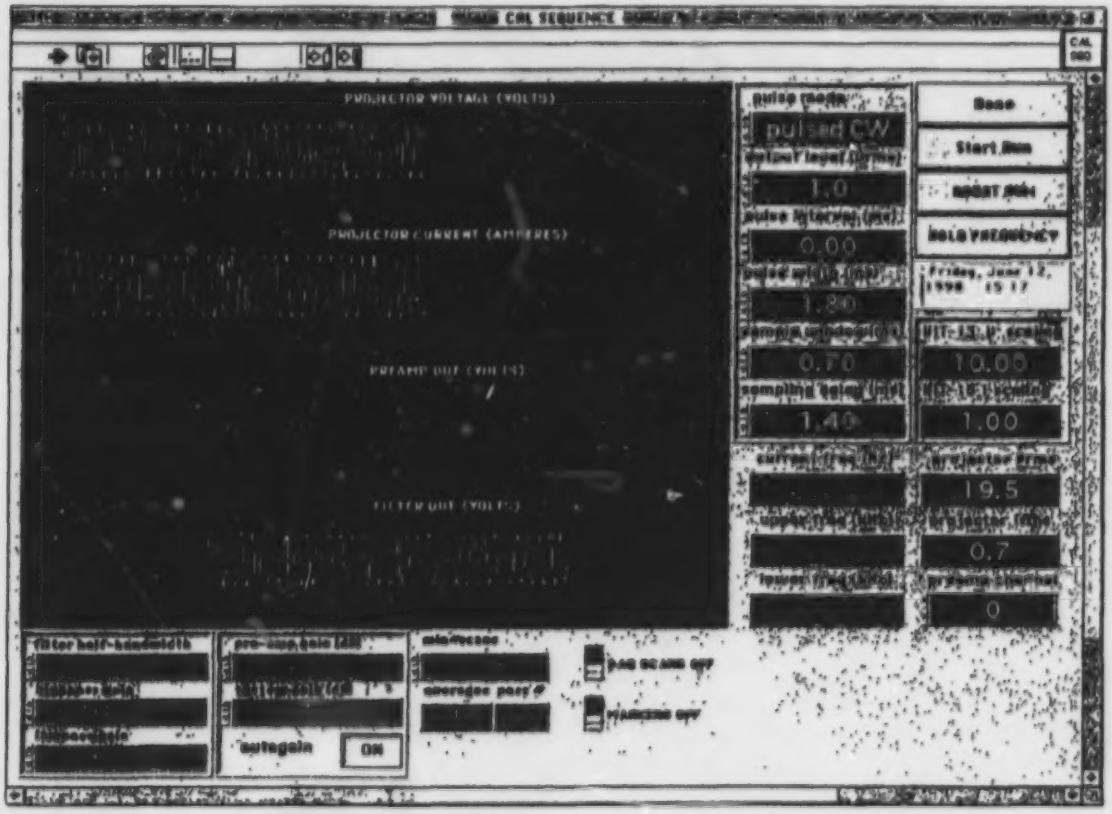

Figure 5-11 CAL SEQUENCE front panel

Acquired data graphs

During a calibration run, data are sampled from the projector voltage and current and hydrophone voltage signals. The sampled data can be viewed in real time in the data scan graphs, shown in Figure 5-12. As for all the graphs, both X and Y axes can be set to autoscale, or axes values can be fixed to values which you enter. The displayed data are projector voltage (Vpj); projector current (Ipj); preamp output voltage (Vpa); and filter output (Vfl).

The Ipj and Vpa graphs include markers which indicate the beginning and end of the data samples used to calculate the transducer calibration curves. This feature is very helpful in determining the optimum values for pulse sampling.

Figure 5-12 Sampled data graphs

The DAQ SCANS OFF and MARKERS OFF controls are used to turn off the graphs and markers to speed up the data acquisition.

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Acquiring the calibration data

Press *Start Run* to begin the calibration run. While the calibration is underway, you can turn the graphs and markers on and off as desired. You can abort the run using the *ABORT RUN* button. To stop the program from advancing to the next frequency, press the *HOLD FREQUENCY* button. When the run is completed, press *Done* to return to the calibration mode panel, where the resulting calibration plot will be displayed.

During the run the *projector Vrms* and projector Irms controls indicator show the applied projector voltage, in rms volts, at the current frequency. The *preamp channel* control may be used to select the RTS 3510B preamp multiplexor input channel. It is normally set automatically by the program, but can be changed if desired.

6 Using Transmit Response Mode

Starting Transmit Response using tone pulse or CW

You activate the transmit response calibration procedure from the *TRANSCAL* main panel. The front panel will startup as shown in Figure 6-1.

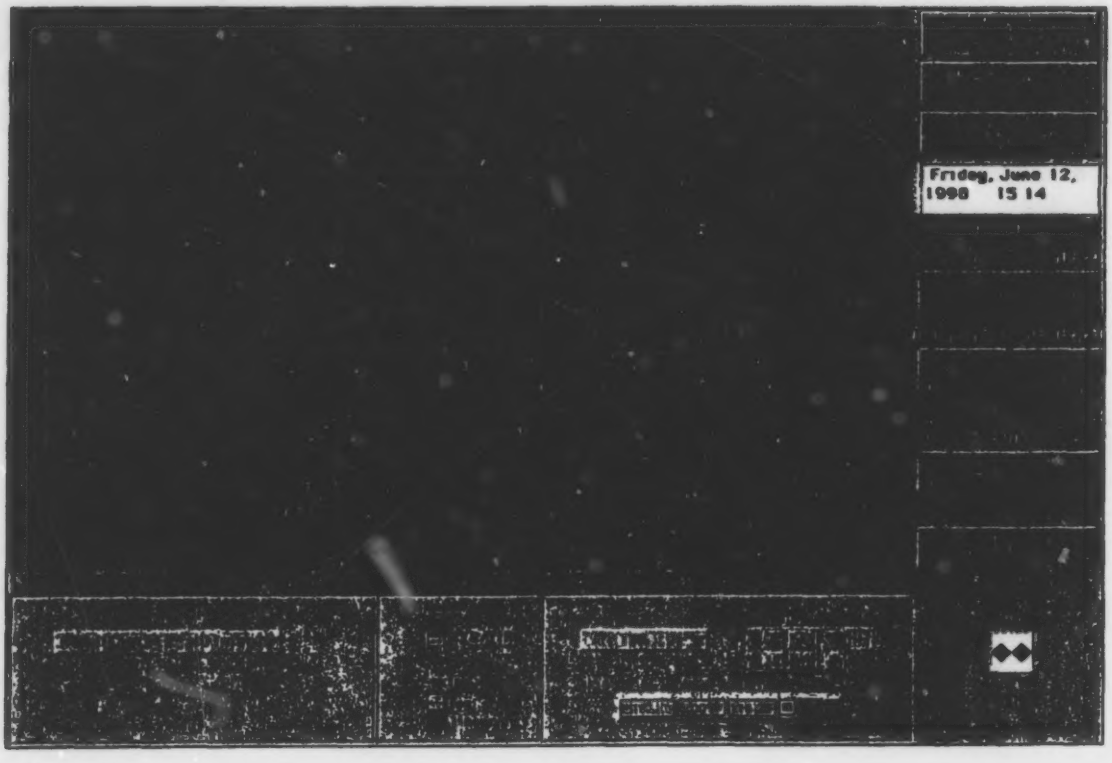


Figure 6-1 Transmit Response front panel

Transmit Response Calibration step-by-step

This section will present a simple guide to the basic operations of transmit response calibration. All required parameters have default values, so it is possible to execute a calibration simply by pressing the Acquire Cal Data button. Typically it will be necessary to change some values or settings for the actual experiment. The instructions below assume autogain will be used. If autogain is OFF, then you should setup the projector drive and signal gains as described in Chapter 5.

Step 1: Startup

Startup as described above. This will bring up the CAL SEQUENCE panel, introduced in Chapter 5.

Step 2: Check the current settings

Check that the current settings are appropriate for your calibration experiment.

Step 3: Check the frequency range

The current frequency settings are reported in the *upper frequency (kHz)* and *lower frequency (kHz)* indicators. If new settings are required, use TRANSCAL main panel to enter new values.

Step 4: Run the calibration

Press *Acquire Cal Data* to begin the calibration run. While the calibration is underway, you can turn the graphs and markers on and off as desired. You can abort the run using the *ABORT RUN* button. To stop the program from advancing to the next frequency, press the *HOLD FREQUENCY* button. When the run is completed, the graphs will be updated with the calibration results. Different graphs, for example TVR or TIR, can be viewed using the graph selection control to select the desired graph type for display.

Step 5 Print the results

Use the *Plot Results* button to get printed plots, or to save the calibration data to a file.

Controls and indicators

Modal Controls

The controls shown in Figure 6-2 redirect control to other front panels. This section briefly describes the function of the controls. The sections detailing the purpose and operation of the resulting front panels follows later in this chapter.

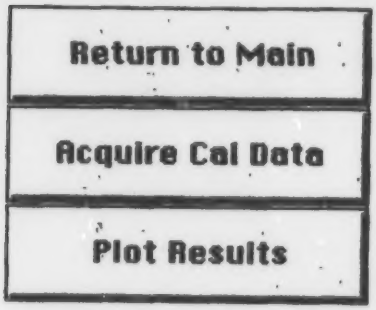


Figure 6-2 Modal controls

Return to Main

This button returns control to the TRANSCAL main panel, from which other calibration procedures can be accessed, or the session can be ended.

Acquire Cal Data

This button brings up the CAL SEQUENCE panel.

Plot Results

This button is used to plot calibration curves or save the calibration data to a file.

Transmitting Response graph

The *Transmitting Response* graph (Figure 6-3) displays the Transmitting Voltage Response (TVR) or Transmitting Current Response (TIR) based on the selection. TVR is displayed, as a function of frequency, as an equivalent sound pressure level in units of decibels relative to one microPascal per volt at a distance of one metre. TIR units are dB re 1 µPa/A @ 1m. You can change the X and Y scale minimum and maximum values by typing into the fields directly, or by editing the values using the standard LabVIEW graph editing pop-up menus. When the graphs are plotted, the current values are transferred to the plotted output. That is, what-you-see-is-what-you-get.

Figure 6-3 Transmit Response graph

TVR/TIR graph controls

The graph type displayed in the transmitting response graph is selected by pressing on the TVR/TIR selection button, dragging the cursor to the desired selection, and releasing the mouse button. The graph controls are shown in Figure 6-4.

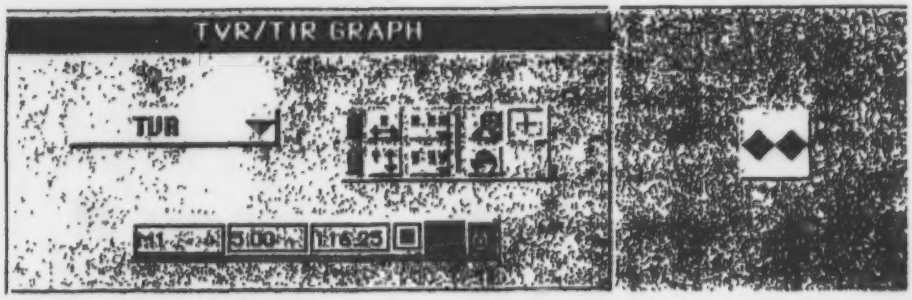


Figure 6-4 Selecting TVR/TIR graph

The other controls shown are standard LabVIEW graph controls. The graph cursor control moves the cursor within the graph area. Typically, the cursor is locked to the TVR plot. The cursor coordinates (frequency (kHz)and TVR) are updated beside the bottom right corner of the plot area.

Admittance/Impedance graph

The admittance/impedance graph (Figure 6-5) displays the projector admittance or impedance based on the current selection. Both admittance and impedance can be displayed as the real and imaginary parts, or as magnitude and phase information. As for the transmit response graph, you can change the X and Y scale axes for display and plotting.

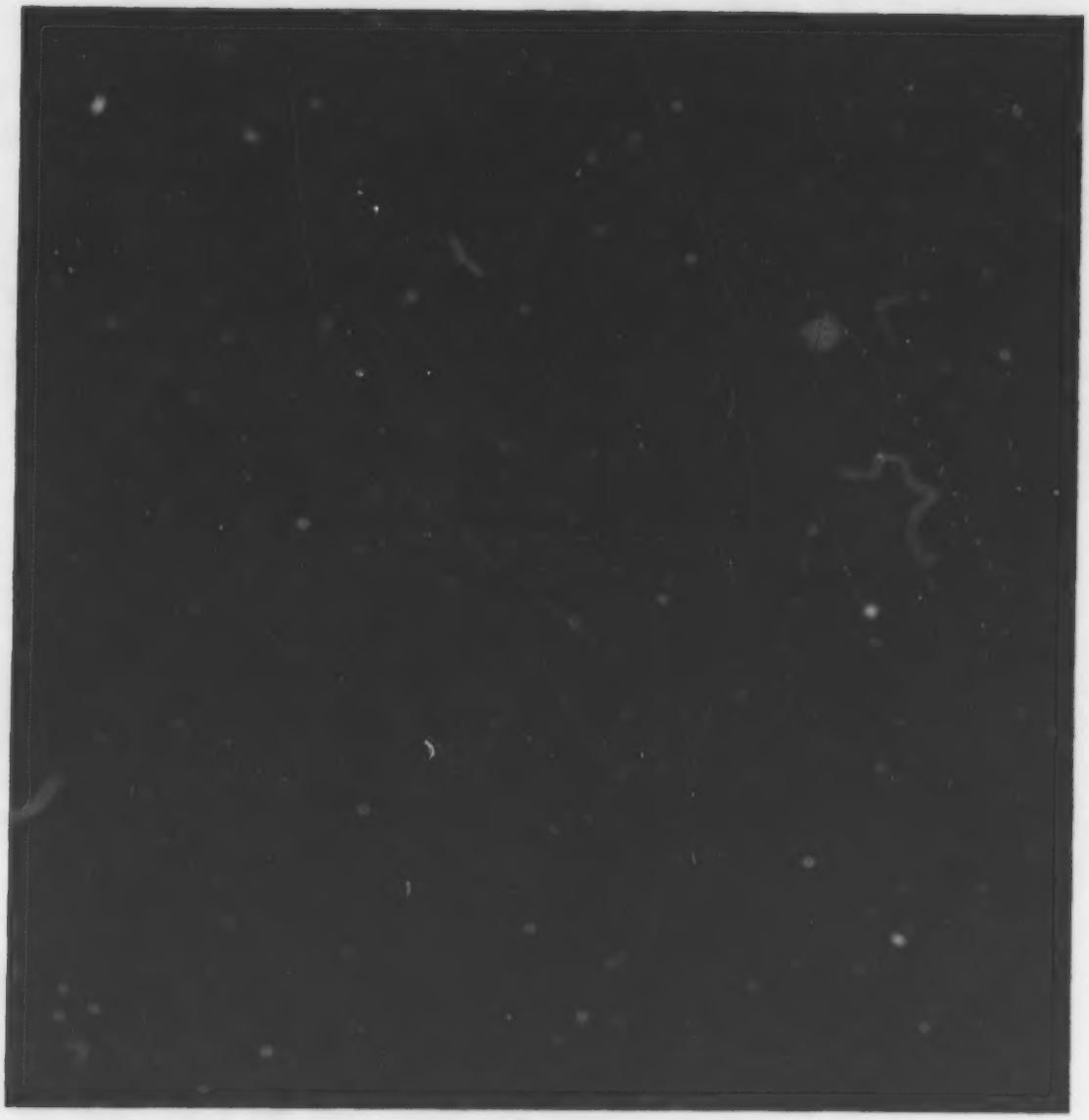


Figure 6-5 Admittance/Impedance graph

Admittance/Impedance graph controls

The graph type displayed in the admittance/impedance graph is selected by pressing on the graph type selection button, dragging the cursor to the desired selection, and releasing the mouse button. The appearance of the control during selection is shown in Figure 6-6.

Figure 6-6 Selecting Admittance/Impedance graph

Display Mode Controls

The controls in Figure 6-7 are used to select which graphs are displayed after a calibration run. Also, there is a control to change the TVR/TIR and ADM/IMP X-axis display mode between log and linear.

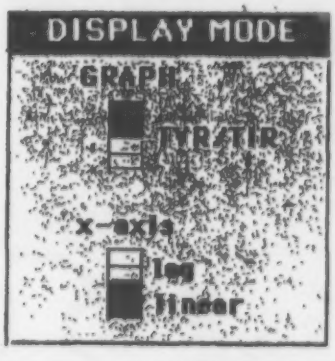


Figure 6-7 Display Mode Controls

Getting results

Pressing the *Plot Results* button from the TRANSMIT RESPONSE front panel will cause the dialog shown in Figure 6-8 to appear. This gives you some flexibility in selecting which results you wish to generate. The available results are:

- plot the transmitting response graph on the attached LaserWriter printer,
- plot the admittance or impedance graph on the attached LaserWriter printer, and
- save the calibration results to a data file for archiving or additional processing.

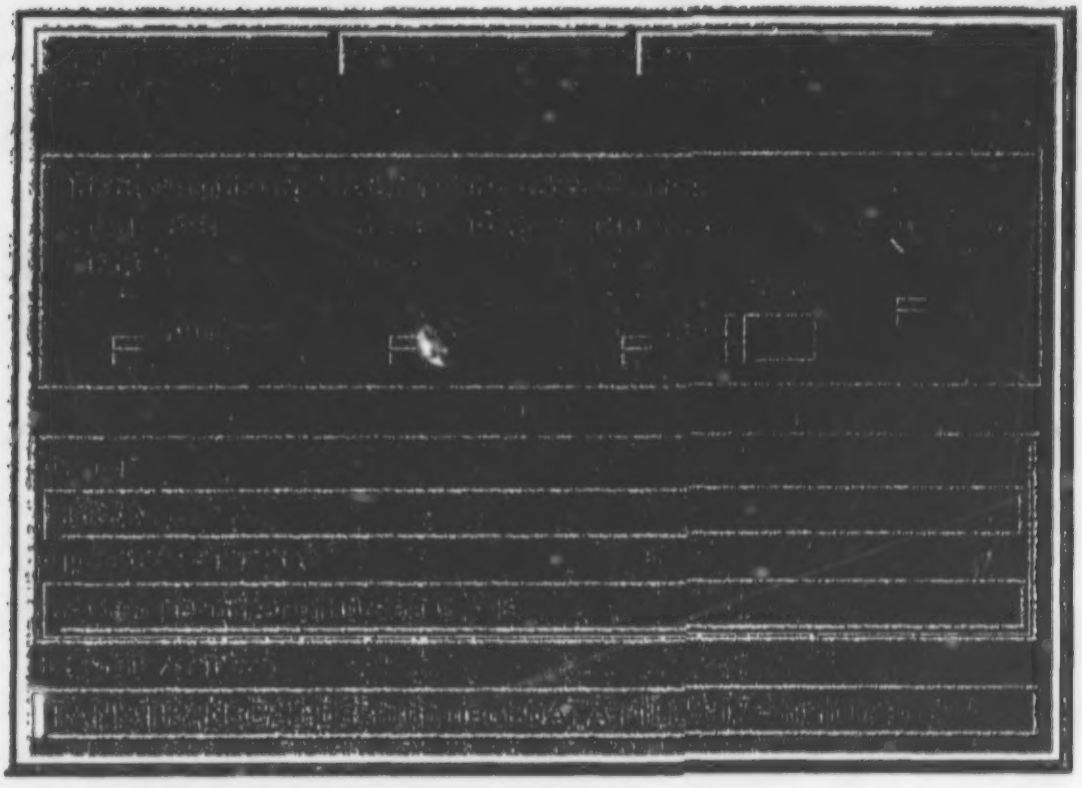


Figure 6-8 Results dialog

Use the *Transmitting Response Graph*, *Admittance/Impedance Graph*, and *Plot to Data File* switches to select which results you want. By default, the data is always saved to a data file, to ensure the data does not inadvertently get lost. The data file is a tab-delimited spreadsheet text file, which can be read by most word processing, spreadsheet, or data processing programs. Sample results are given in Appendix A.

The *Filter Graphs* control allows you to filter out spurious data points, if any exist, on the printed results. The filter is a median filter, good for removing high frequency noise without corrupting valid transitions. The filter rank is selectable, and has a default value of 2, which is good for most noise spikes. Since filtering is rarely required, the default is not to filter the graphs.

Comments will appear on the printed plots, and will be saved in the data file. New comments are entered simply by typing in the fields provided. The *datafile/folder* indicator shows the current folder and filename prefix. To select a new folder, press the *Select Datafile* button at the top of the dialog panel. The actions to do this are the same as from the main panel, and are described in the following section.

When you have finished making your selection of desired results, press *Generate Results*. The data file will be created and the results will be saved to the file. The graphs will be printed in the background. There will be a short delay as the results are spooled to memory for background printing. The amount of time required for printing to complete will depend on the level of network activity, and can be several minutes. To check the progress of the printing, use the Print Monitor utility.

7 Using Receiving Response Mode

Starting Receiving Response using tone pulse or CW

You activate the receiving response calibration procedure from the *TRANSCAL* main panel. The front panel will startup as shown in Figure 7-1.

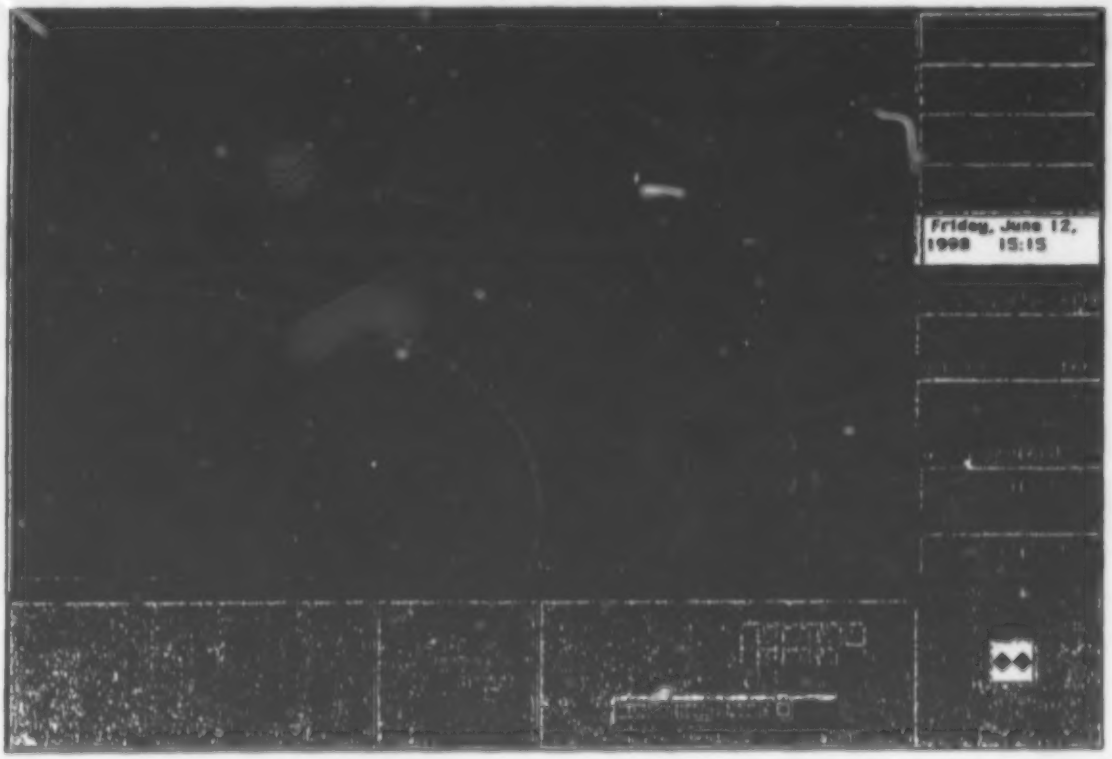


Figure 7-1 Receiving Response front panel

Receiving Response Calibration step-by-step

This section will present a simple guide to the basic operations of receiving response calibration. All required parameters have default values, so it is possible to execute a calibration simply by pressing the *Acquire Standard* and *Acquire Unknown* buttons. Typically it will be necessary to change some values or settings for the actual experiment. The instructions below assume autogain will be used. If autogain is OFF, then you should setup the projector drive and signal gains as described Chapter 5.

Step 1: Startup

Startup as described above. This will bring up the CAL SEQUENCE panel, introduced in Chapter 5.

Step 2: Check the current settings

Check that the current settings are appropriate for your calibration experiment.

Step 3: Check the frequency range

The current frequency settings are reported in the *upper frequency (kHz)* and *lower frequency (kHz)* indicators. If new settings are required, use TRANSCAL main panel to enter new values.

Step 4: Run the calibration

Two passes are required to complete the hydrophone calibration; one for the standard hydrophone, and one for the test or unknown hydrophone. These passes can be done in any order; the calibration curve will be completed when both passes have been completed. Multiple calibrations can be completed as standard, test#1, test#2, standard, etc.; or one standard can be used for multiple test passes.

Press *Acquire Standard* to begin the calibration run for the standard hydrophone. While the calibration is underway, you can turn the graphs and markers on and off as desired. You can abort the run using the *ABORT RUN* button. To stop the program from advancing to the next frequency, press the *HOLD FREQUENCY* button.

When the run is completed, replace the standard hydrophone with the test hydrophone. If necessary, update the test hydrophone separation value. Press *Acquire Unknown* to begin the calibration run for the unknown hydrophone. When both hydrophones have been run, the graph will show the hydrophone sensitivity.

Step 5 Print the results

Use the Results button to get printed plots, or to save the calibration data to a file.

Controls and indicators

Modal Controls

The controls shown in Figure 7-2 redirect control to other front panels. This section briefly describes the function of the controls. The sections detailing the purpose and operation of the resulting front panels follows later in this chapter.

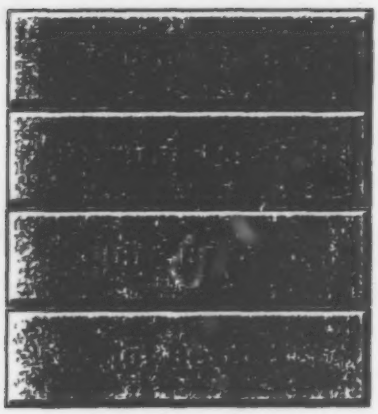


Figure 7-2 Modal controls

Return to Main

This button returns control to the TRANSCAL main panel, from which other calibration procedures can be accessed, or the session can be ended.

Acquire Standard

This button starts the data acquisition process for the standard hydrophone.

Acquire Unknown

This button starts the data acquisition process for the unknown hydrophone.

Plot Results

This button is used to plot calibration curves or save the calibration data to a file.

Receiving Response graph

The *Receiving Response* graph (Figure 7-3) displays the Receiving Response, also referred to as the hydrophone sensitivity graph. Hydrophone sensitivity is displayed, as a function of frequency, as a voltage in units of decibels relative to one volt per microPascal of sound pressure at a distance of one metre. You can change the X and Y scale minimum and maximum values by typing into the fields directly, or by editing the values using the standard LabVIEW graph editing pop-up menus. When the graphs are plotted, the current values are transferred to the plotted output. That is, what-you-see-is-what-you-get.

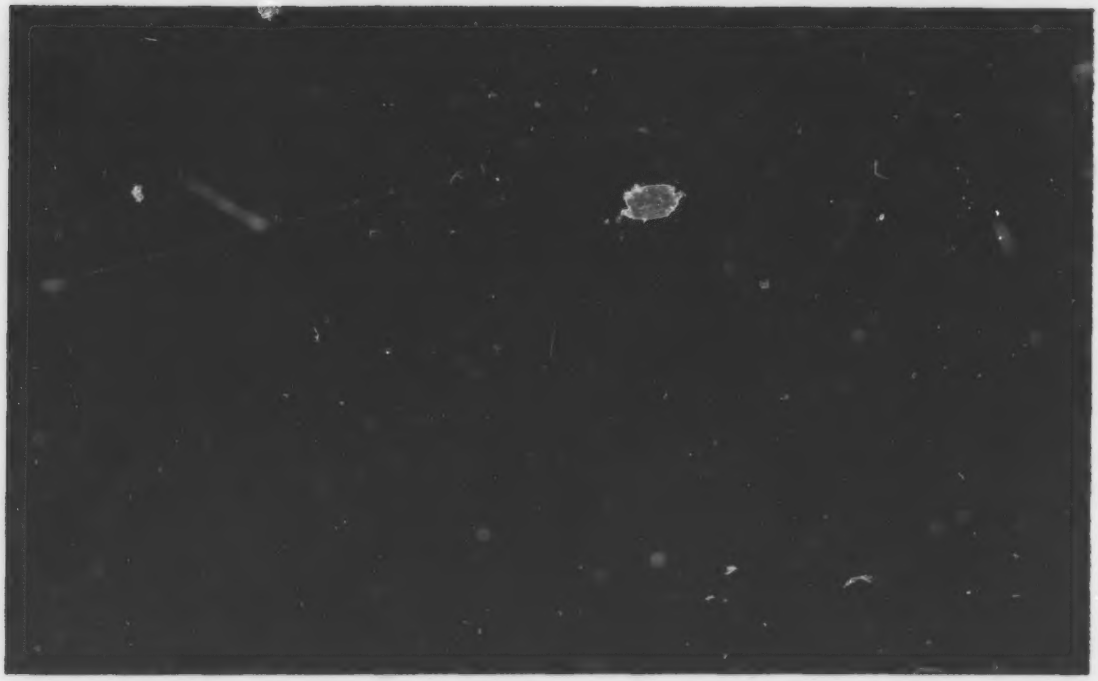


Figure 7-3 Receiving Response graph

Hydrophone sensitivity graph controls

The hydrophone sensitivity graph controls are shown in Figure 7-4. Final results appear only in the form of a hydrophone sensitivity graph. Therefore, there are no selection options for the graph type.

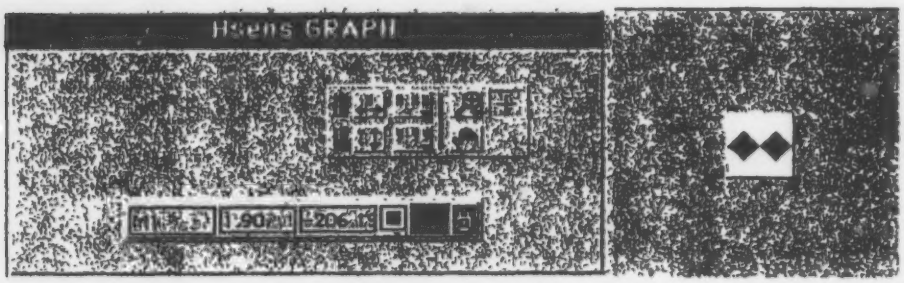


Figure 7-4 Hydrophone sensitivity graph controls

The other controls shown are standard LabVIEW graph controls. The graph cursor control moves the cursor within the graph area. Typically, the cursor is locked to the plot. The cursor coordinates (frequency (kHz)and SPL) are updated beside the bottom right corner of the plot area.

Display Mode Controls

The control in Figure 7-5 is used to change the X-axis display mode between log and linear.

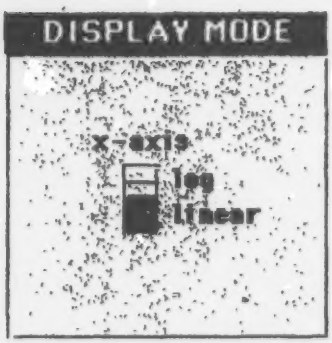


Figure 7-5 Display Mode Control

Getting results

Pressing the *Plot Results* button from the RECEIVING RESPONSE front panel will cause the dialog shown in Figure 7-6 to appear. This gives you some flexibility in selecting which results you wish to generate. The available results are:

- plot the receiving response graph on the attached LaserWriter printer,
- save the calibration results to a data file for archiving or additional processing.

Figure 7-6 Results dialog

Use the *Receiving Response Graph*, and *Plot to Data File* switches to select which results you want. By default, the data is always saved to a data file, to ensure the data does not inadvertently get lost. The data file is a tab-delimited spreadsheet text file, which can be read by most word processing, spreadsheet, or data processing programs. Sample results are given in Appendix A.

The *Filter Graphs* control allows you to filter out spurious data points, if any exist, on the printed results. The filter is a median filter, good for removing high frequency noise without corrupting valid transitions. The filter rank is selectable, and has a default value of 2, which is good for most noise spikes. Since filtering is rarely required, the default is not to filter the graphs.

Comments will appear on the printed plots, and will be saved in the data file. New comments are entered simply by typing in the fields provided. The *datafile/folder* indicator shows the current folder and filename prefix. To select a new folder, press the *Select Datafile* button at the top of the dialog panel. The actions to do this are the same as from the main panel, and are described in the following section.

When you have finished making your selection of desired results, press *Generate Results*. The data file will be created and the results will be saved to the file. The graphs will be printed in the background. There will be a short delay as the results are spooled to memory for background printing. The amount of time required for printing to complete will depend on the level of network activity, and can be several minutes. To check the progress of the printing, use the Print Monitor utility.

8 Using Directional Response Mode

Starting Directivity

You activate the directivity response calibration procedure from the *TRANSCAL* main panel. The front panel will startup as shown in Figure 8-1.

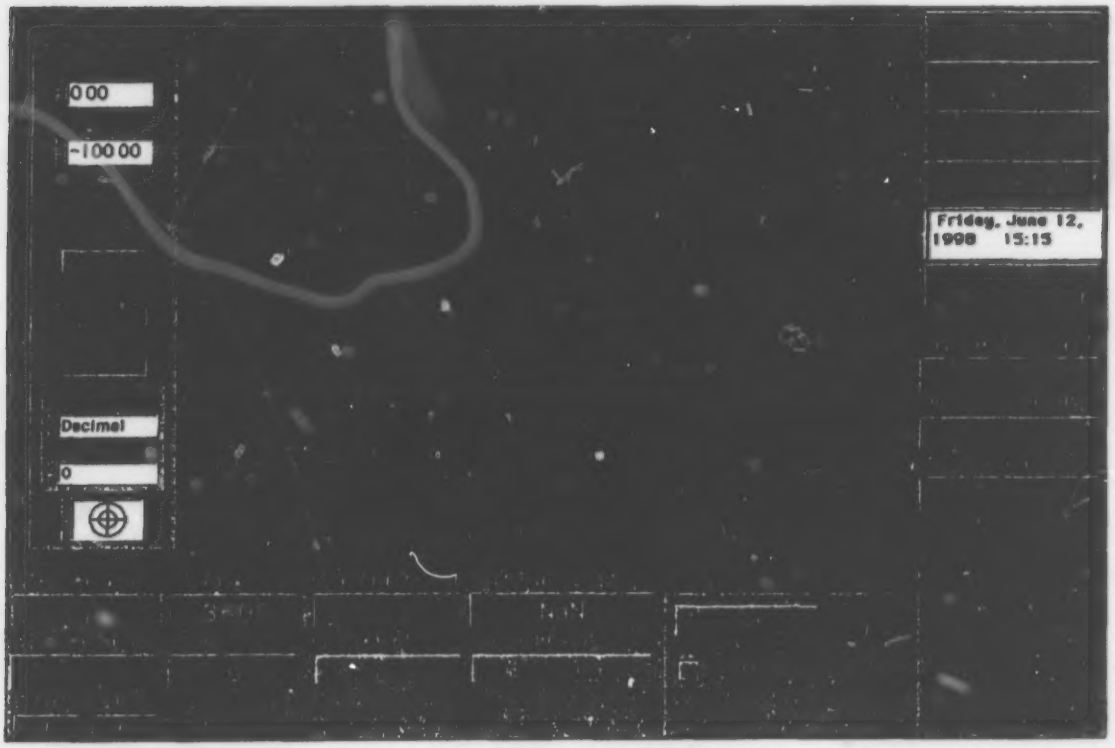


Figure 8-1 Directivity Response front panel

Directivity Response Calibration step-by-step

This section will present a simple guide to the basic operations of directivity response calibration. All required parameters have default values, so it is possible to execute a calibration simply by pressing the *Acquire Cal Data* button. Typically it will be necessary to change some values or settings for the actual experiment.

Step 1: Startup

Startup as described above. This will bring up the CAL SEQUENCE panel, introduced in Chapter 5.

Step 2: Check the current settings

Check that the current settings are appropriate for your calibration experiment.

Step 3: Check the frequency range

The current frequency settings are reported in the *upper frequency (kHz)* and *lower frequency (kHz)* indicators. If new settings are required, use *Frequencies* button to enter new values. This step is described later in this chapter.

Step 4: Run the calibration

Before beginning a calibration run, the rotation station has to be positioned. If the station shaft encoder readout panel has just been powered on, the station must be rotated past the zero-degree point. This will allow the encoder interface to lock on to the zero pulse. Position the station 10 or more degrees in advance of the zero position. Set the rotation direction control on the Directivity front panel to match that of the rotation station drive control panel.

To initiate the calibration run, press the *Acquire Cal Data* button on the front panel. Immediately start the station rotation by turning the speed control knob. Typical settings are 25 in the Tank, and 18 on the Barge. Exact speed setting is not critical -- too slow and the run will take too long; too fast and the system might miss pulses. You can abort the run using the *ABORT RUN* button. When the run has been completed, the graph will be updated with the calibration results.

Step 5 Print the results

Use the Results button to get printed plots, or to save the calibration data to a file.

Controls and indicators

Modal Controls

The controls shown in Figure 8-2 redirect control to other front panels, or cease operation. This section briefly describes the function of the controls. The sections detailing the purpose and operation of the resulting front panels follows later in this chapter.

Figure 8-2 Modal controls

Return to Main

This button returns control to the TRANSCAL main panel, from which other calibration procedures can be accessed, or the session can be ended.

Frequencies

This button is used to redirect control to the *Setup Frequencies* front panel, used to set the calibration frequency range.

Acquire Cal Data

This button starts the calibration process.

Plot Results

This button is used to plot calibration curves or save the calibration data to a file.

Directional Response graph

The *Directional Response* polar graph (Figure 8-3) displays the Directional Response of the test transducer. Response is displayed, as a function of frequency, in units of decibels relative to the maximum response. Alternately, the data may be displayed in cartesian form, shown in Figure 8-4.

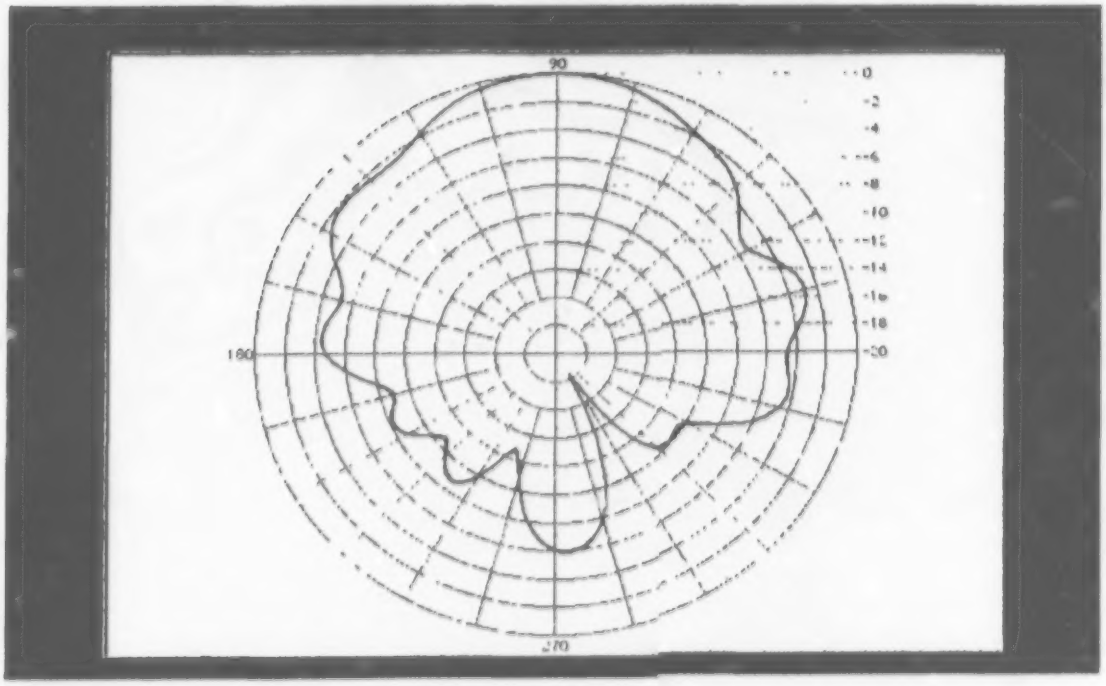


Figure 8-3 Directional Response polar graph

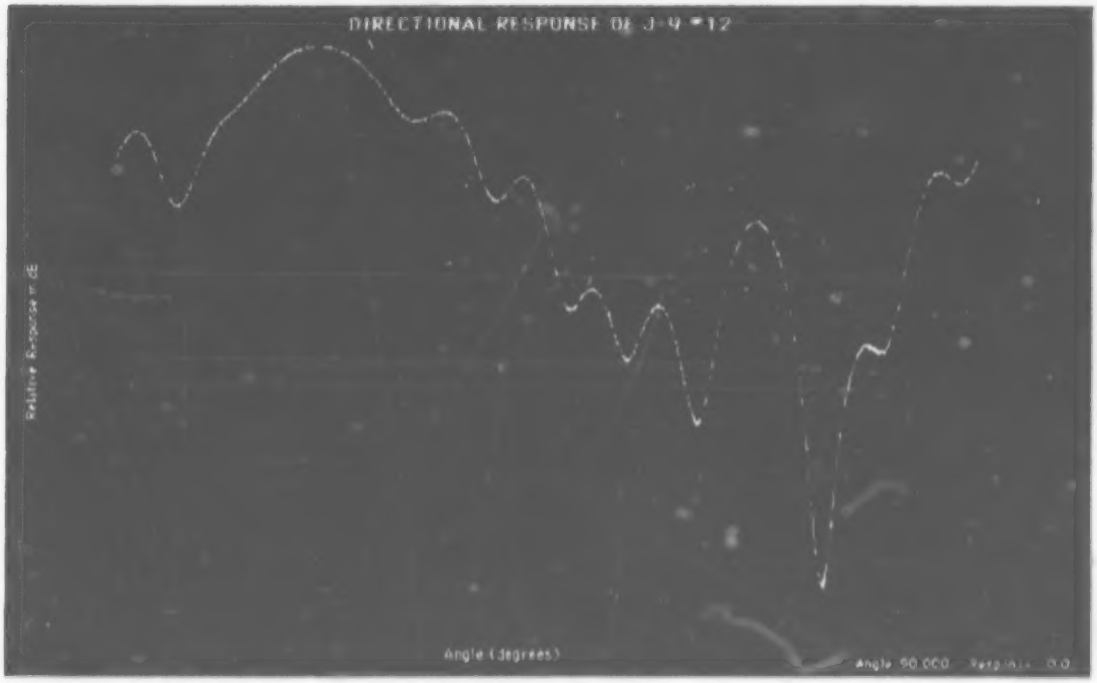


Figure 8-4 Directional Response cartesian graph

Display Mode Controls

The graph type displayed in the directional response graph is selected by pressing on the directional plot type selection button, dragging the cursor to the desired selection, and releasing the mouse button. The display mode control is shown in Figure 8-5.

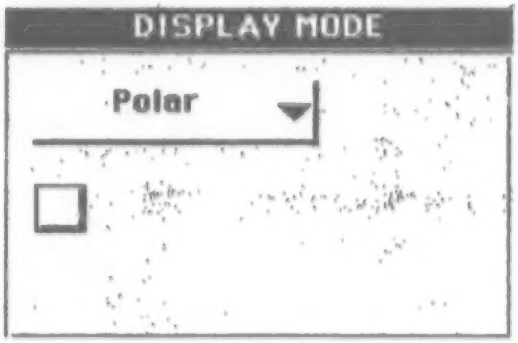


Figure 8-5 Display Mode Control

Calibration run controls

The calibration run control is used to abort the calibration process. The *ABORT RUN* button stops the current scan.

Current Settings

Current Settings, shown in Figure 8-6, is a collection of controls and indicators which provide an interactive reporting of the current process status.

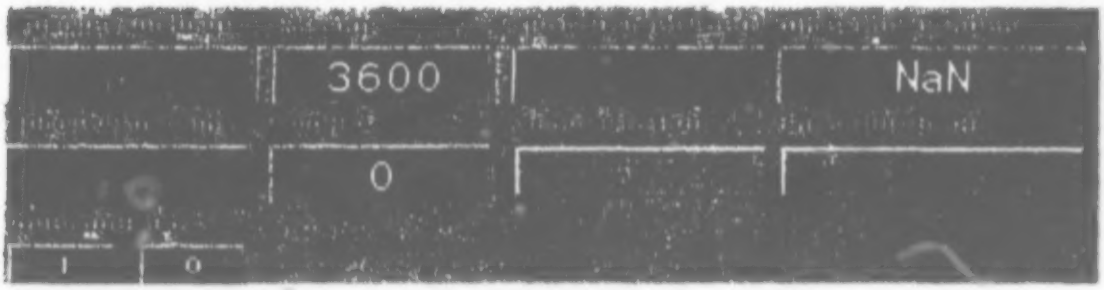


Figure 8-6 Current Settings controls and indicators

projector Vrms

This indicator shows the applied projector voltage, in rms volts, at the current frequency.

projector Irms

This indicator shows the applied projector current, in rms amperes, at the current frequency.

averages

This control is used to show the number of passes which get averaged to calculate the final calibration curve.

pass #

This indicator shows the current pass number, providing feedback on the progress of the calibration.

 # scans

This control is used to enter the number of data points to acquire. The points are acquired in 0.1 degree increments. Typically, this value is set to 3600, to give 360 degrees of rotation.

scan #

This indicator displays the current scan in progress.

shaft offset (deg)

This control is used to enter the offset angle from the station zero-degree pulse position and the symmetry axis (ϕ=0) position for the transducer.

scan rotation

This control selects the scan direction to match the station rotation controller panel setting.

directivity index

This indicator displays the calculated directivity index for the plot.

directivity axis

A symmetry axis may be specified for calculating the directivity axis.

The positive X-axis (θ=90°, ϕ=0°) shall be the direction of zero azimuth and coincide with any existing horizontal acoustic axis (i.e. maximum response); ϕ is equal to the azimuth angle.

[redacted]

The positive Y-axis (θ=90°, ϕ=90°) shall be the direction of 90° azimuth and will be outward from the designated right-hand side of the transducer as viewed from the transducer.

Directivity Controls

Some additional controls, specific to the directional response mode, are positioned to the left of the directional response graph. These interactive controls, shown in Figure 8-7, determine the polar plot appearance.

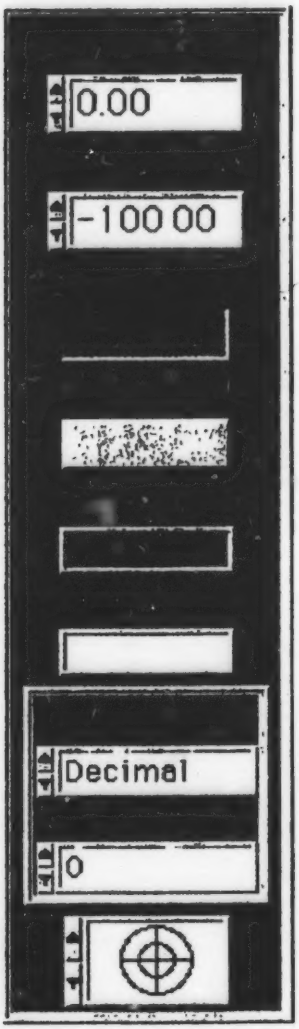


Figure 8-7 Directivity controls and indicators

Selecting the calibration frequency range

The Setup Calibration Frequencies front panel (Figure 8-8) is used to modify the current frequency selections. The area on the left shows the current settings for the frequency range. Pressing the button below this area will return control to the calibration front panel, without changing the current settings.

New values are entered in the area to the right. Up to five frequencies may be specified. For each data point (0.1 degrees) one frequency is processed. The next frequency is processed on the next data point. Cycling through the frequencies continues until the scan is complete. Thus adding frequencies reduces the measurement resolution for any one frequency.

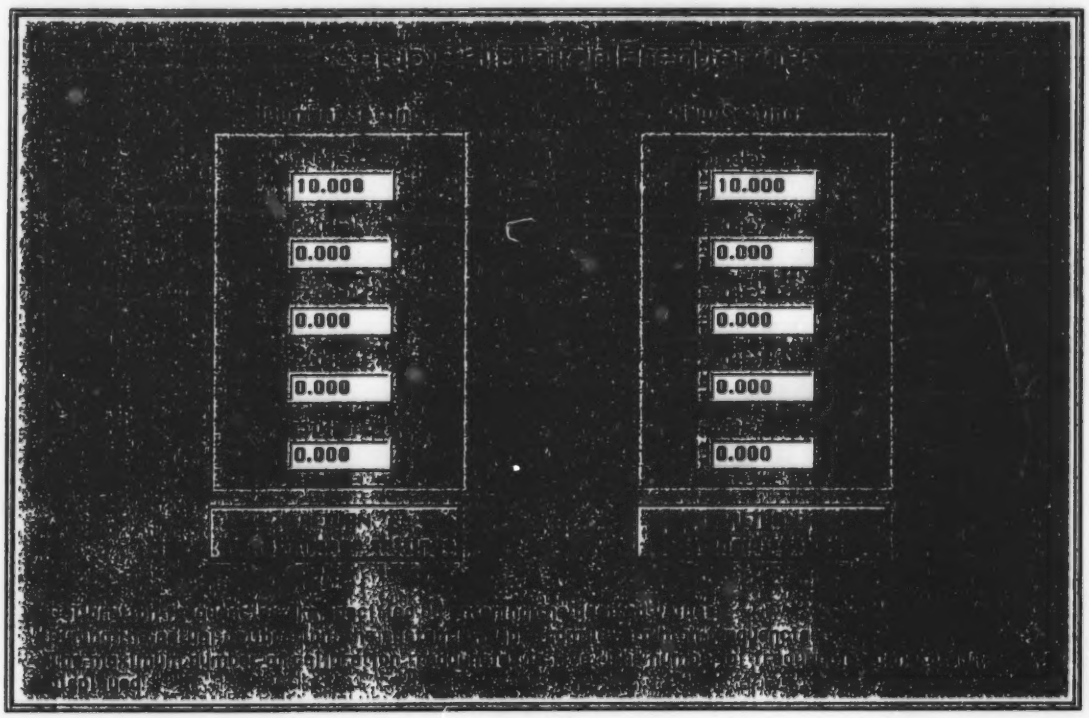


Figure 8-8 Setting the frequency range

Getting results

Pressing the *Results* button from the DIRECTIONAL RESPONSE front panel will cause the dialog shown in Figure 8-9 to appear. This gives you some flexibility in selecting which results you wish to generate. The available results are:

- plot the directional response polar graph on the attached LaserWriter printer,
- plot the directional response cartesian graph on the a... :d LaserWriter printer,
- save the calibration results to a data file for archiving or additional processing.

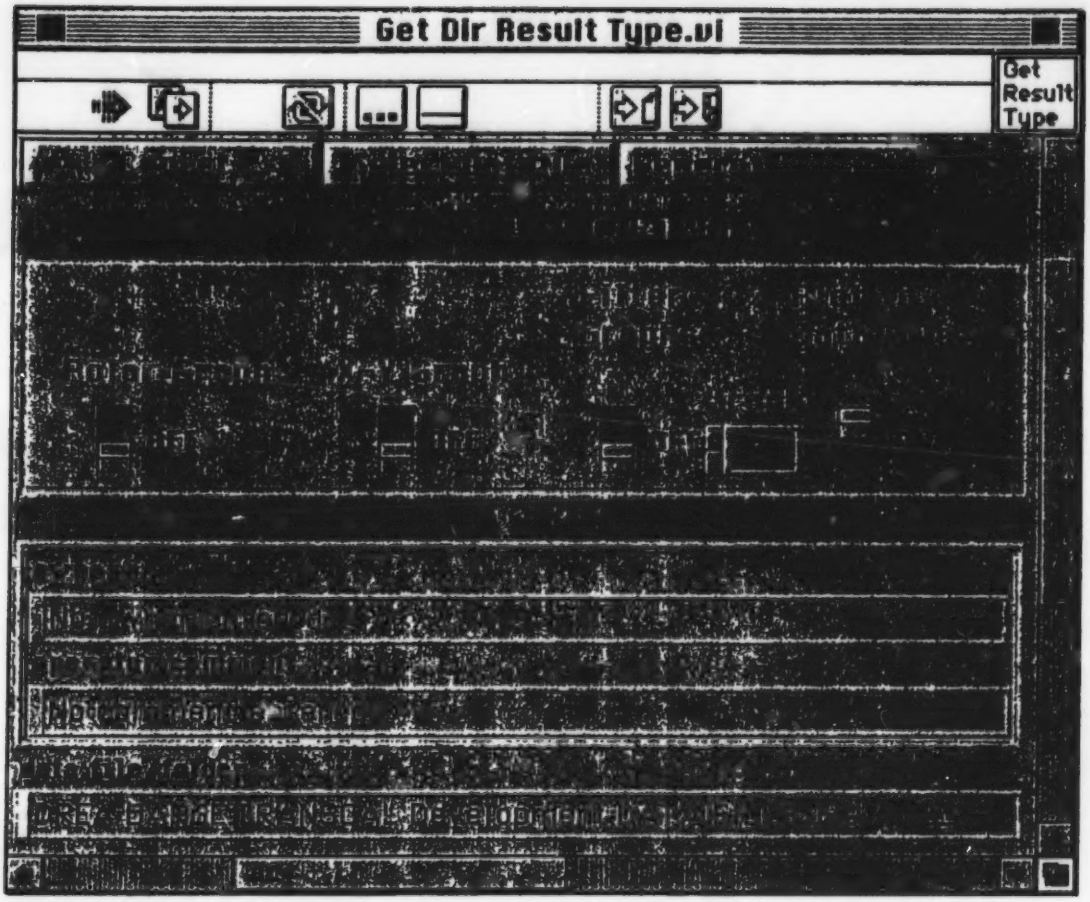


Figure 8-9 Results dialog

Use the *Polar Graph*, *X-Y Graph*, and *Plot to Data File* switches to select which results you want. By default, the data is always saved to a data file, to ensure the data does not inadvertently get lost. The data file is a tab-delimited spreadsheet text file, which can be read by most word processing, spreadsheet, or data processing programs. Sample results are given in Appendix A.

The *Filter Graphs* control allows you to filter out spurious data points, if any exist, on the printed results. The filter is a median filter, good for removing high frequency noise without corrupting valid transitions. The filter rank is selectable, and has a default value of 2, which is good for most noise spikes. Since filtering is rarely required, the default is not to filter the graphs.

Comments will appear on the printed plots, and will be saved in the data file. New comments are entered simply by typing in the fields provided. The *datafile/folder* indicator shows the current folder and filename prefix. To select a new folder, press the *Select Datafile* button at the top of the dialog panel. The actions to do this are the same as from the main panel, and are described in the following section.

When you have finished making your selection of desired results, press *Generate Results*. The data file will be created and the results will be saved to the file. The graphs will be printed in the background. There will be a short delay as the results are spooled to memory for background printing. The amount of time required for printing to complete will depend on the level of network activity, and can be several minutes. To check the progress of the printing, use the Print Monitor utility.

9 Using Reciprocity Mode

Starting Reciprocity using tone pulse or CW

You activate the receiving response calibration procedure from the *TRANSCAL* main panel. The front panel will startup as shown in Figure 9-1.

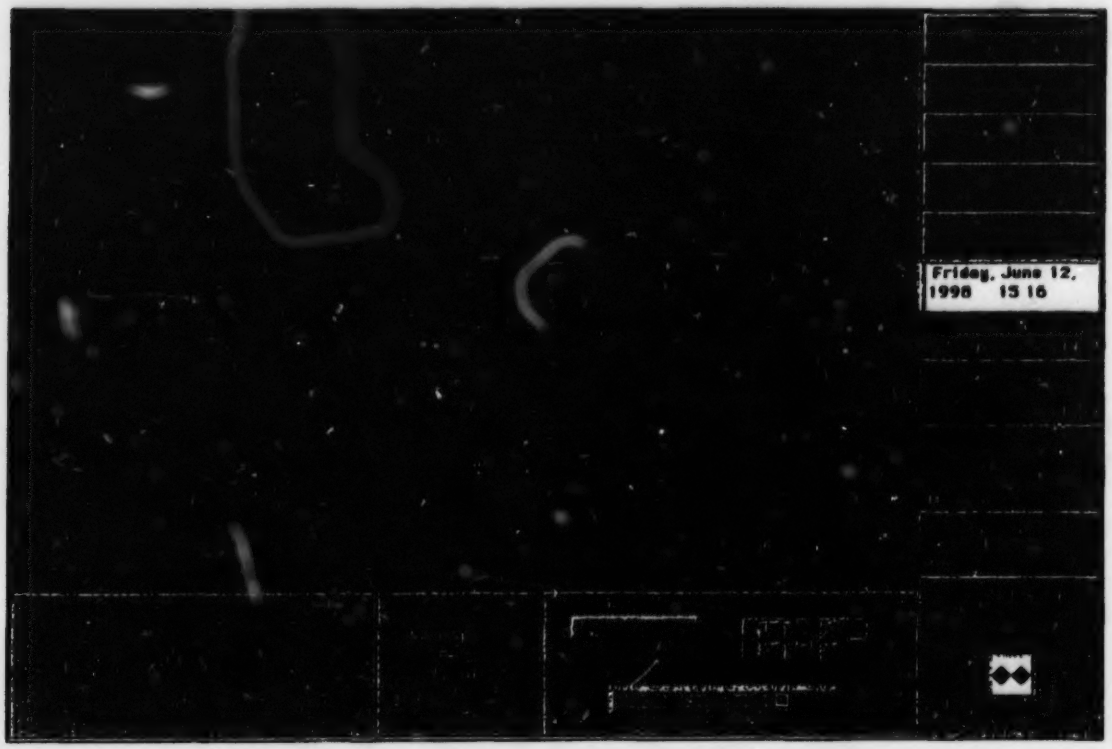


Figure 9-1 Reciprocity front panel

Reciprocity Calibration step-by-step

This section will present a simple guide to the basic operations of reciprocity calibration. All required parameters have default values, so it is possible to execute a calibration simply by pressing the *Acquire Pass 1*, *Acquire Pass 2*, and *Acquire Pass 3* buttons, and moving the transducers as required. Typically it will be necessary to change some values or settings for the actual experiment. The instructions below assume autogain will be used. If autogain is OFF, then you should setup the projector drive and signal gains as described in the sections later in the chapter.

Step 1: Startup

Startup as described above.

Step 2: Check the current settings

Check that the current settings are appropriate for your calibration experiment.

Step 3: Check the frequency range

The current frequency settings are reported in the *upper frequency (kHz)* and *lower frequency (kHz)* indicators. If new settings are required, use TRANSCAL main panel to enter new values.

Step 4: Run the calibration

Three passes are required to complete the hydrophone calibration; one for the projector and hydrophone, one for the projector and reciprocal transducer, and one for the hydrophone and reciprocal transducer. These passes can be done in any order; the calibration curve will be completed when all passes have been completed.

Press *Acquire Pass 1* to begin the calibration run for the hydrophone and projector. While the calibration is underway, you can turn the graphs and markers on and off as desired. You can abort the run using the *ABORT RUN* button. To stop the program from advancing to the next frequency, press the *HOLD FREQUENCY* button.

When the run is completed, replace the hydrophone with the reciprocal transducer. Press *Acquire Pass 2* to begin the calibration run for the reciprocal transducer. Do not adjust the projector drive levels between Pass 1 and Pass 2. It is important to place the reciprocal transducer acoustic centre at the same location as was the hydrophone's acoustic centre.

When both transducers have been driven by the projector, replace the reciprocal transducer with the hydrophone, again being careful to position it correctly. Replace the projector with the reciprocal transducer. Set up the drive levels if necessary. Press *Acquire Pass 3* to begin the calibration pass.

Step 5 Print the results

Use the Results button to get printed plots, or to save the calibration data to a file.

Controls and indicators

Modal Controls

The controls shown in Figure 9-2 redirect control to other front panels. This section briefly describes the function of the controls. The sections detailing the purpose and operation of the resulting front panels follows later in this chapter.

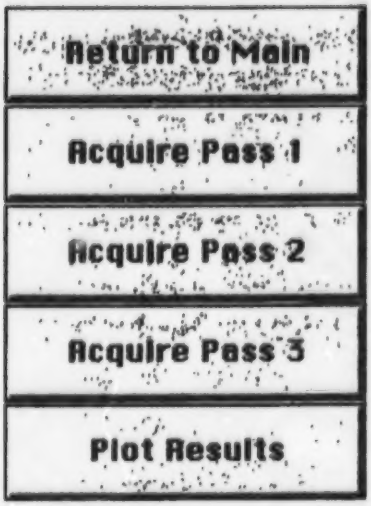


Figure 9-2 Modal controls

Return to Main

This button returns control to the TRANSCAL main panel, from which other calibration procedures can be accessed, or the session can be ended.

Acquire Pass 1

This button starts the data acquisition process for the hydrophone driven by the projector.

Acquire Pass 2

This button starts the data acquisition process for the reciprocal transducer driven by the projector.

Acquire Pass 3

This button starts the data acquisition process for the hydrophone driven by the reciprocal transducer.

Plot Results

This button is used to plot calibration curves or save the calibration data to a file.

Receiving Response graph

The *Receiving Response* graph (Figure 9-3) displays the Receiving Response, also referred to as the hydrophone sensitivity graph. Hydrophone sensitivity is displayed, as a function of frequency, as a voltage in units of decibels relative to one volt per microPascal of sound pressure at a distance of one metre. You can change the X and Y scale minimum and maximum values by typing into the fields directly, or by editing the values using the standard LabVIEW graph editing pop-up menus. When the graphs are plotted, the current values are transferred to the plotted output. That is, what-you-see-is-what-you-get.

Figure 9-3 Receiving Response graph

Hydrophone graph controls

The hydrophone sensitivity graph controls are shown in Figure 9-4. Final results may be presented as one of three results:

Ms

This graph displays the receive response, or sensitivity, of the hydrophone under test.

Mt

This graph displays the receive response, or sensitivity, of the reciprocal transducer.

St

This graph displays the transmit response of the reciprocal transducer.

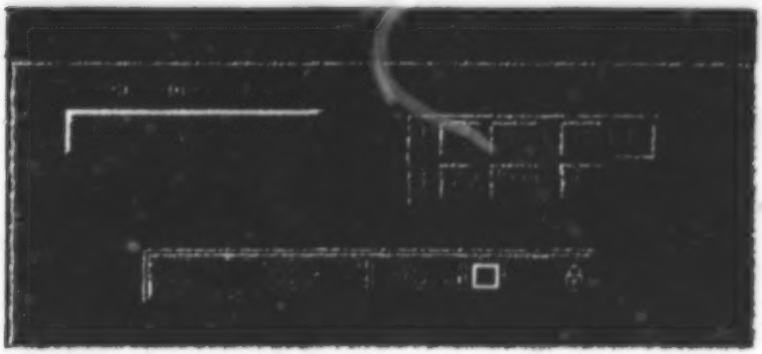


Figure 9-4 Hydrophone sensitivity graph controls

The other controls shown are standard LabVIEW graph controls.

Display Mode Controls

The only display mode control is a control to change the X-axis display mode between log and linear.

Getting results

Pressing the *Results* button from the RECIPROCITY front panel will cause the dialog shown in Figure 9-5 to appear. This gives you some flexibility in selecting which results you wish to generate. The available results are:

- plot the displayed graph on the attached LaserWriter printer, and
- save the calibration results to a data file for archiving or additional processing.

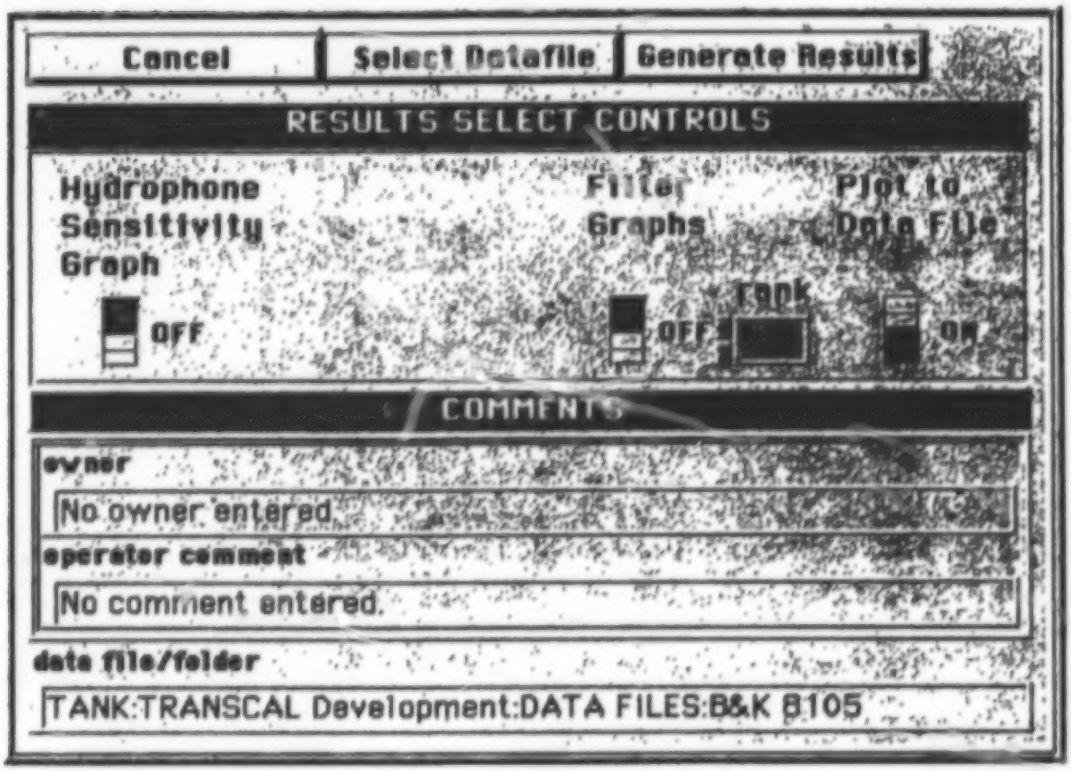


Figure 9-5 Results dialog

Use the *Hydrophone Sensitivity Graph*, and *Plot to Data File* switches to select which results you want. By default, the data is always saved to a data file, to ensure the data does not inadvertently get lost. The data file is a tab-delimited spreadsheet text file, which can be read by most word processing, spreadsheet, or data processing programs. Sample results are given in Appendix A.

The *Filter Graphs* control allows you to filter out spurious data points, if any exist, on the printed results. The filter is a median filter, good for removing high frequency noise without corrupting valid transitions. The filter rank is selectable, and has a default value of 2, which is good for most noise spikes. Since filtering is rarely required, the default is not to filter the graphs.

Comments will appear on the printed plots, and will be saved in the data file. New comments are entered simply by typing in the fields provided. The *datafile/folder* indicator shows the current folder and filename prefix. To select a new folder, press the *Select Datafile* button at the top of the dialog panel. The actions to do this are the same as from the main panel, and are described in the following section.

When you have finished making your selection of desired results, press *Generate Results*. The data file will be created and the results will be saved to the file. The graphs will be printed in the background. There will be a short delay as the results are spooled to memory for background printing. The amount of time required for printing to complete will depend on the level of network activity, and can be several minutes. To check the progress of the printing, use the Print Monitor utility.

10 Using Standalone Admittance Mode

Starting Admittance Mode using tone pulse or CW

You activate the transmit response calibration procedure from the *TRANSCAL* main panel. The front panel will startup as shown in Figure 10-1.

Figure 10-1 Admittance/Impedance front panel

Admittance Calibration step-by-step

This section will present a simple guide to the basic operations of admittance calibration. This mode is identical to transmit response mode, so all procedures for that mode will apply here as well. For the standalone mode, however, it is not required to have a hydrophone. This is optional, and calibrations may be done in air if desired.

◆ **Note** The autogain control must be off for in-air calibrations ◆

All required parameters have default values, so it is possible to execute a calibration simply by pressing the Acquire Cal Data button. Typically it will be necessary to change some values or settings for the actual experiment. The instructions below assume autogain will be used. If autogain is OFF, then you should setup the projector drive and signal gains as described in Chapter 5.

Step 1: Startup

Startup as described above. This will bring up the CAL SEQUENCE panel, introduced in Chapter 5.

Step 2: Check the current settings

Check that the current settings are appropriate for your calibration experiment.

Step 3: Check the frequency range

The current frequency settings are reported in the *upper frequency (kHz)* and *lower frequency (kHz)* indicators. If new settings are required, use TRANSCAL main panel to enter new values.

Step 4: Run the calibration

Press *Acquire Cal Data* to begin the calibration run. While the calibration is underway, you can turn the graphs and markers on and off as desired. You can abort the run using the *ABORT RUN* button. To stop the program from advancing to the next frequency, press the *HOLD FREQUENCY* button. When the run is completed, the graphs will be updated with the calibration results. Different graphs, for example TVR or TIR, can be viewed using the graph selection control to select the desired graph type for display.

Step 5 Print the results

Use the *Plot Results* button to get printed plots, or to save the calibration data to a file.

Controls and indicators

Modal Controls

The modal controls are similar to transmit response mode. The one exception is the *Cable Effects* button, which executes the compensation for cable effects on the calibration.

Admittance/Impedance graph

The admittance/impedance graph displays the projector admittance or impedance based on the current selection. Both admittance and impedance can be displayed as the real and imaginary parts, or as magnitude and phase information. As for the transmit response graph, you can change the X and Y scale axes for display and plotting.

Admittance/Impedance graph controls

The graph type displayed in the admittance/impedance graph is selected by pressing on the graph type selection button, dragging the cursor to the desired selection, and releasing the mouse button. The appearance of the control is shown in Figure 10-2.

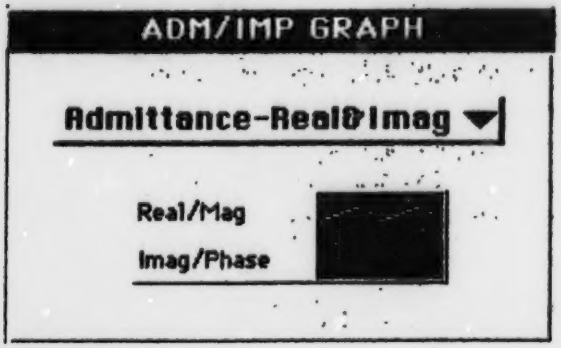


Figure 10-2 Selecting Admittance/Impedance graph type

Display Mode Controls

The controls in Figure 10-3 are used enter the range of frequencies displayed on the graphs. Also, there is a control to change the X-axis display mode between log and linear.

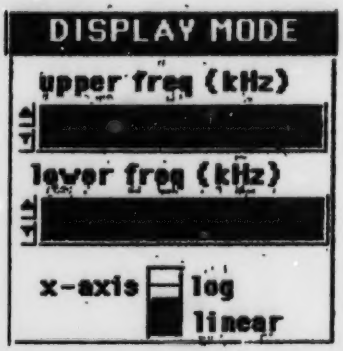


Figure 10-3 Display Mode Controls

Cable Effects Controls

The controls in Figure 10-4 are used enter the cable effects parameters.

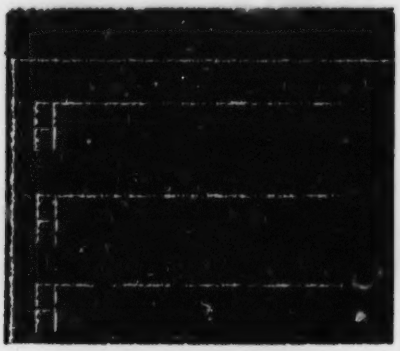


Figure 10-4 Cable Effects Controls

Getting results

Results can be printed by pressing the *Plot Results* button from the front panel. This procedure is identical to transmit response mode, described in Chapter 6.

Part 3 Appendixes

Appendix A: Sample Results for Transmit Response Mode

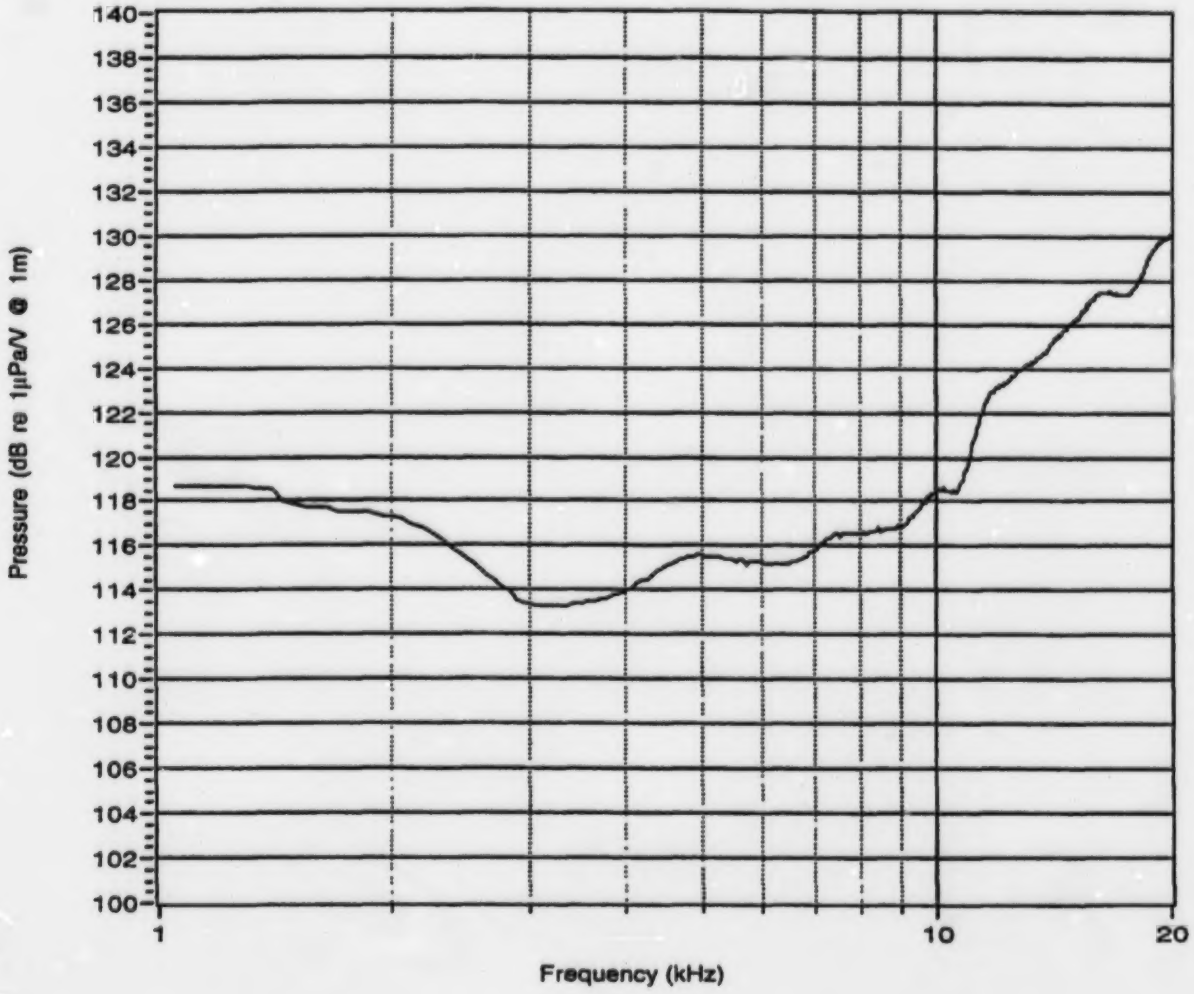
Defence Research Establishment Atlantic
P.O. Box 1012, Dartmouth, NS, CANADA, B2Y 3Z7

7/4/99

TRANSMITTING VOLTAGE RESPONSE

Transducer: J9-12
Owner: DREA
Comments: Test Point H, Transmit Response
PW = 1.2, TW = 0.7, delay = 1.0

Drive voltage: 19.9 Volts
Depth: 1.83 metres
Temperature: 10.00 degrees C
Capacitance: 1.0 nanoFarads
Dissipation: 0.01



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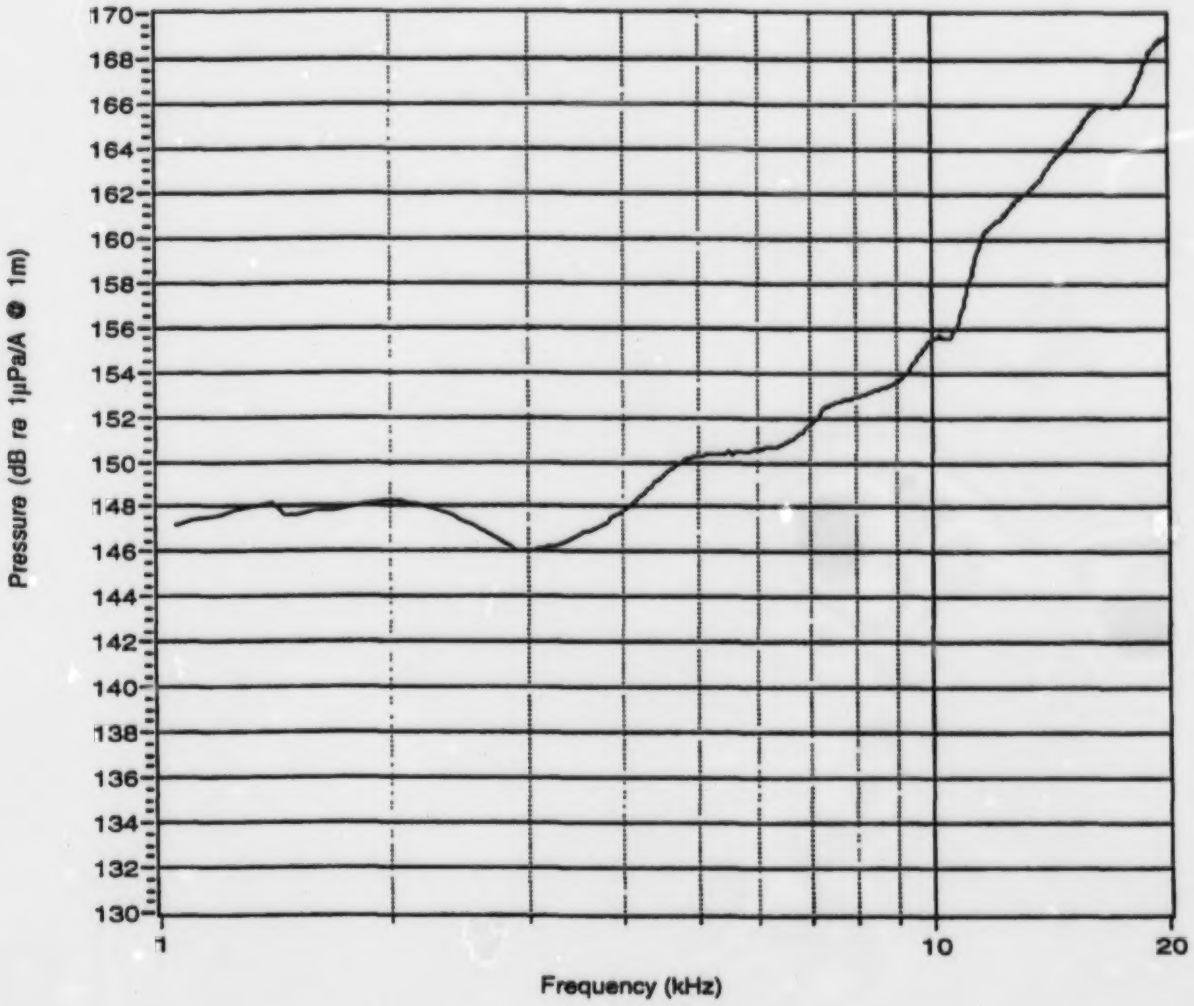
7/4/99

TRANSMITTING CURRENT RESPONSE

Transducer: J9-12
Owner: DREA
Comments: Test Point H, Transmit Response
PW = 1.2, TW = 0.7, delay = 1.0

Drive voltage: 19.9 Volts
Depth: 1.83 metres
Temperature: 10.00 degrees C
Capacitance: 1.0 nanoFarads
Dissipation: 0.01



TRANSCAL DATA FILE					
TYPE	Transmitting Voltage Response				
DATE	3/23/99				
OWNER	DREA				
COMMENT	Test Point K, Transmit Response				
Inner and outer sections					
PW = 10.0, SW = 3.0, delay = 2.75					
PROJECTOR ID	F33 #102				
HYDROPHONE ID	B&K 8106 #452(Rec)				
DEPTH (m)	3.048				
TEMPERATURE (C)	10				
SEPARATION (m)	3.17				
V SCALING	100				
I SCALING	1				
CAPACITANCE	78.2				
DISSIPATION	0.018				
Frequency	Projector Voltage	Projector Current	Hydrophone Voltage	Transmitting Response	
(Hz)	(V)	(I)	(V)	(dB re 1µPa/V)	
1000	126.884	0.063	0.001	85.368	
1250	126.979	0.079	0.001	87.267	
1500	127.417	0.095	0.003	91.944	
1750	127.225	0.111	0.004	95.529	
2000	127.571	0.126	0.005	98.321	
2250	127.9	0.142	0.007	100.887	
2500	127.956	0.158	0.009	103.328	
2750	128.014	0.174	0.012	105.619	
3000	128.429	0.19	0.016	107.672	
3250	128.34	0.206	0.019	109.133	
3500	128.461	0.222	0.021	110.273	
3750	128.847	0.238	0.024	111.197	
4000	129.055	0.253	0.027	112.33	
4250	129.023	0.27	0.031	113.589	
4500	129.228	0.285	0.035	114.702	
4750	129.095	0.302	0.04	115.845	
5000	129.265	0.317	0.046	117.009	

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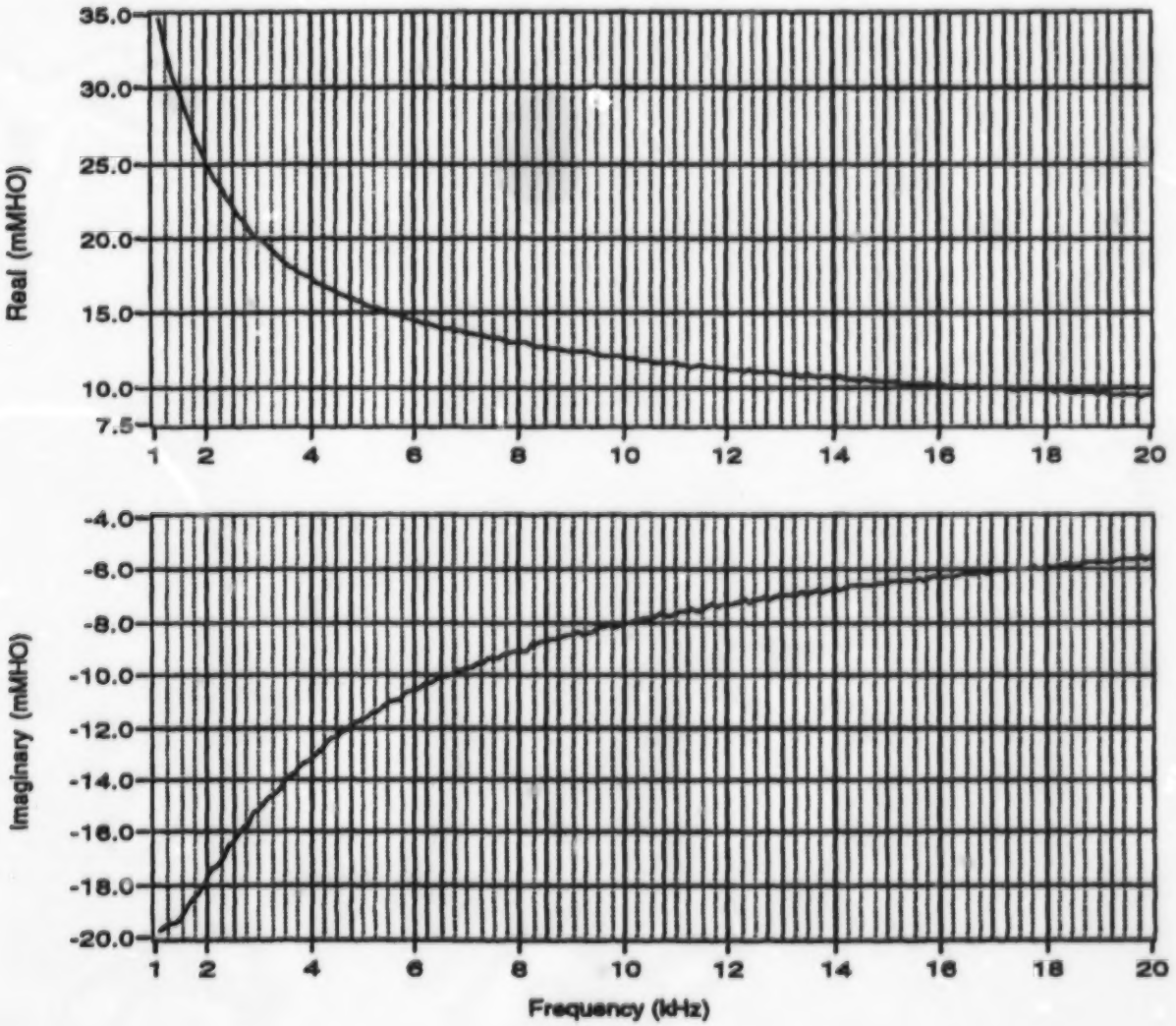
3/26/99

ADMITTANCE

Transducer: J9-11
Owner: DREA
Comments: Test Point H, Transit Response
PW = 1.2, TW = 0.7, delay = 2.4

Drive voltage: 26.0 Volts
Depth: 3.05 metres
Temperature: 10.00 degrees C
Capacitance: 1.0 nanoFarads
Dissipation: 0.01



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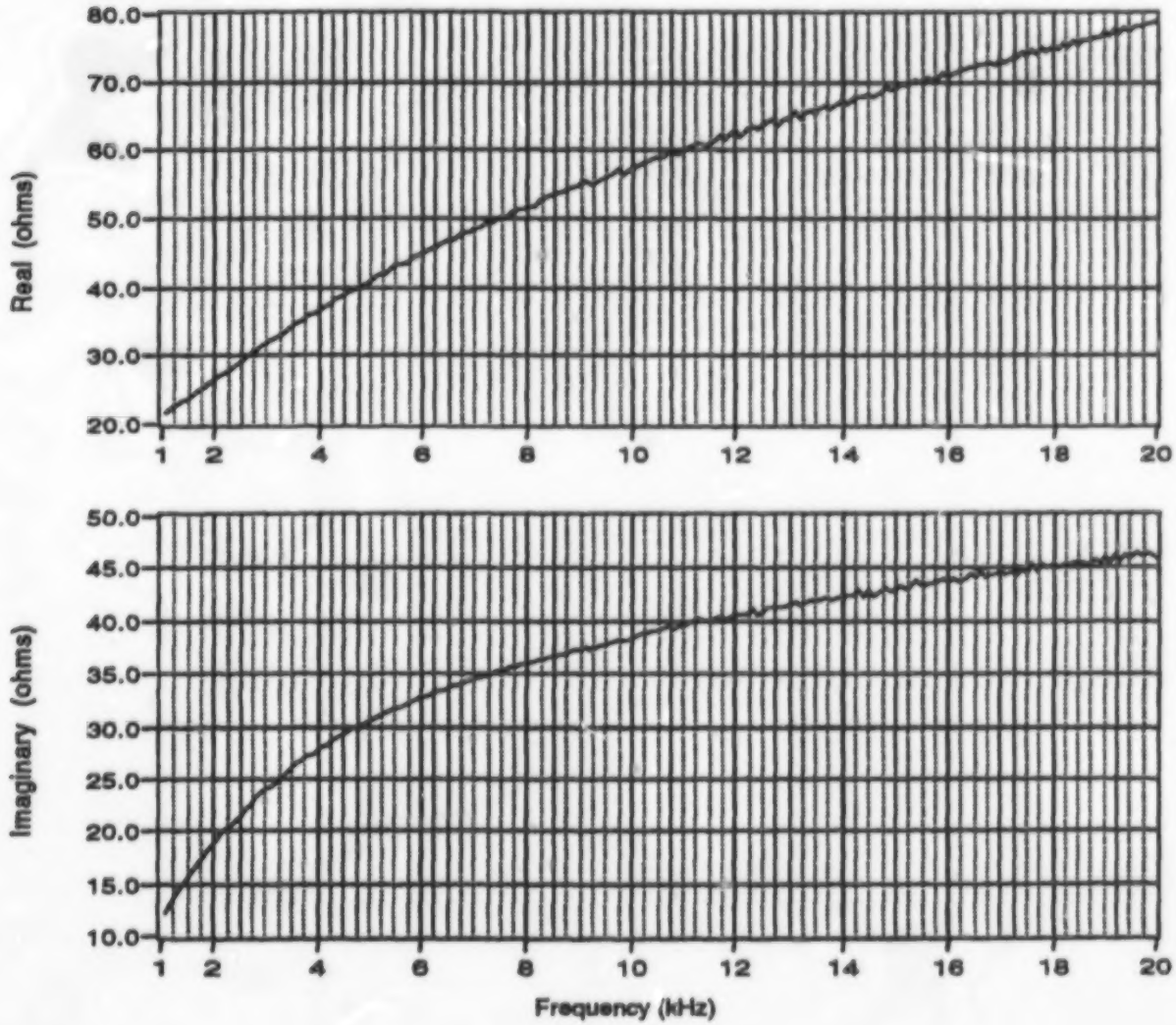
IMPEDANCE

Transducer: J9-11
Owner: DREA
Comments: Test Point H, Transit Response
PW = 1.2, TW = 0.7, delay = 2.4

Drive voltage: 26.0 Volts
Depth: 3.05 metres
Temperature: 10.00 degrees C
Capacitance: 1.0 nanoFarads
Dissipation: 0.01



Appendix B: Sample Results for Receive Response Mode

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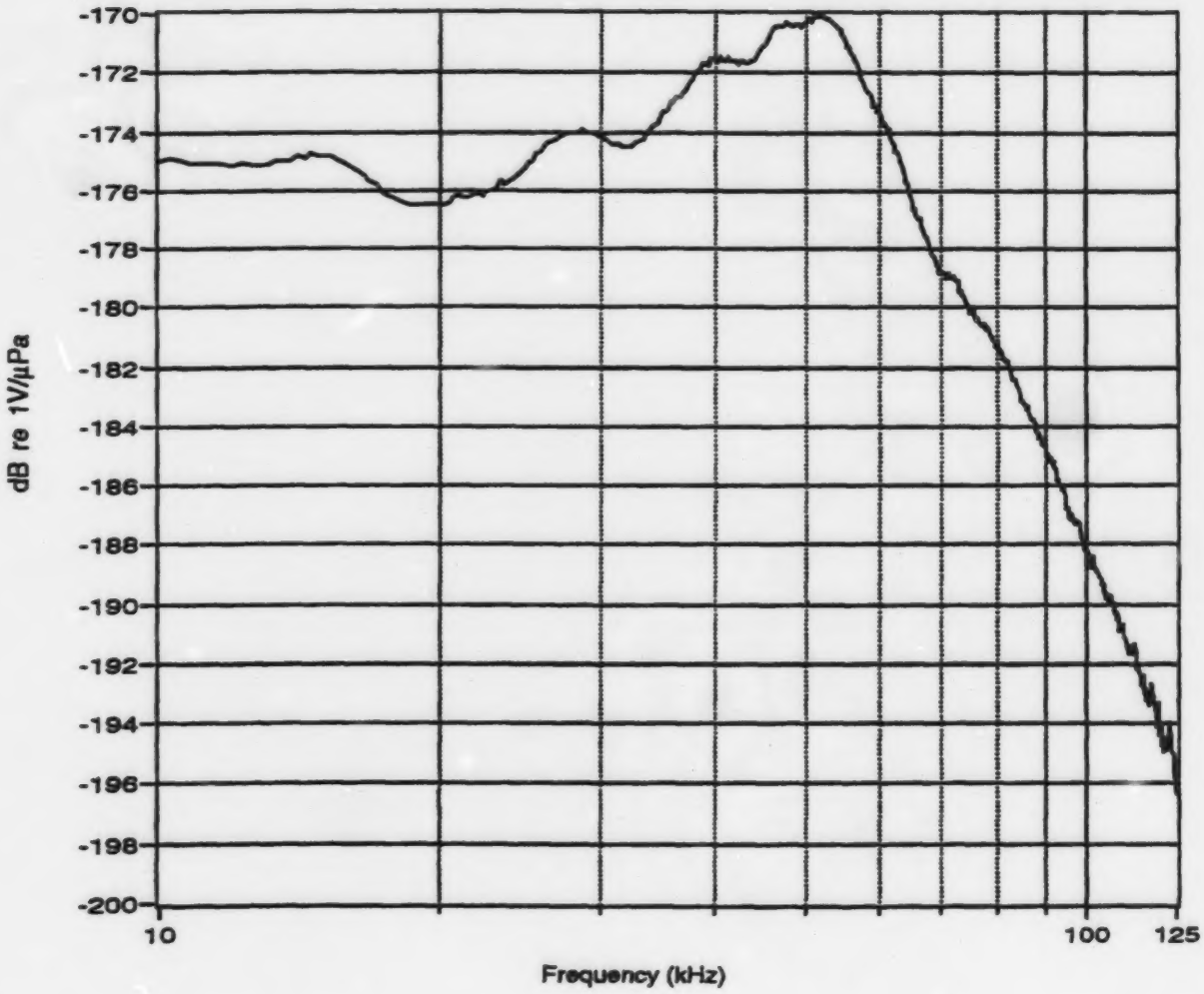
3/22/99

RECEIVING RESPONSE

Projector: F33 #102
Hydrophone: B&K 8106 #453
Owner: DREA
Comments: Test Point L, Receive Response
PW = 0.5, SW = 0.3, delay = 2.25

Drive voltage: 70.7 Volts
Depth: 3.05 metres
Temperature: 10.00 degrees C
Hydrophone Capacitance: 1.0 nanoFarads
Cable Capacitance: 0.0 nanoFarads



TRANSCAL DATA FILE					
TYPE	Receiving Response				
DATE	1997/02/05				
OWNER	D.R.E.A.				
COMMENT	Test calibration plot -- median filter off.				
PROJECTOR ID	J-9 #12				
STD. HYDROPHONE ID	B&K 8100 #806539				
TEST HYDROPHONE ID	B&K 8100 #806539				
DEPTH (m)	1.83				
TEMPERATURE (C)	10				
STD. SEPARATION (m)	1				
TEST SEPARATION (m)	1				
V SCALING	10				
I SCALING	1				
HYDROPHONE CAPACITANCE	36				
CABLE CAPACITANCE	0				
Frequency	Projector Voltage	Projector Current	Standard Voltage	Unknown Voltage	Receiving Response
(Hz)	(V)	(I)	(V)	(V)	(dB re 1V/μPa)
1000.574	28.484	1.088	2.577	2.591	-206.155
1015.811	28.483	1.083	2.595	2.573	-206.273
1031.281	28.507	1.077	2.577	2.567	-206.234
1046.985	28.507	1.071	2.55	2.567	-206.142
1062.929	28.511	1.065	2.537	2.557	-206.132
1079.116	28.575	1.06	2.516	2.546	-206.097
1095.549	28.575	1.053	2.499	2.535	-206.074
1112.233	28.56	1.047	2.535	2.479	-206.396
1129.17	28.549	1.041	2.485	2.506	-206.127
1146.366	28.559	1.036	2.475	2.487	-206.156
1163.823	28.456	1.027	2.47	2.469	-206.206
1181.546	28.444	1.021	2.45	2.449	-206.204
1199.539	28.588	1.017	2.445	2.439	-206.224
1217.806	28.446	1.008	2.392	2.435	-206.044
1236.352	28.549	1.004	2.404	2.395	-206.233
1255.179	28.544	0.997	2.384	2.38	-206.216
1274.294	28.551	0.991	2.368	2.362	-206.222
1293.699	28.555	0.985	2.34	2.349	-206.167
1313.4	28.573	0.979	2.316	2.329	-206.151
1333.401	28.601	0.973	2.308	2.31	-206.193
1353.707	28.479	0.965	2.298	2.299	-206.195
1374.322	28.509	0.959	2.279	2.282	-206.188
1395.25	28.558	0.953	2.26	2.255	-206.22
1416.498	28.598	0.947	2.229	2.235	-206.178
1438.069	28.507	0.94	2.221	2.226	-206.182
1459.969	28.57	0.934	2.195	2.199	-206.187
1482.202	28.471	0.927	2.173	2.174	-206.197
1504.773	28.542	0.921	2.159	2.165	-206.174

Appendix C: Sample Results for Directivity Mode

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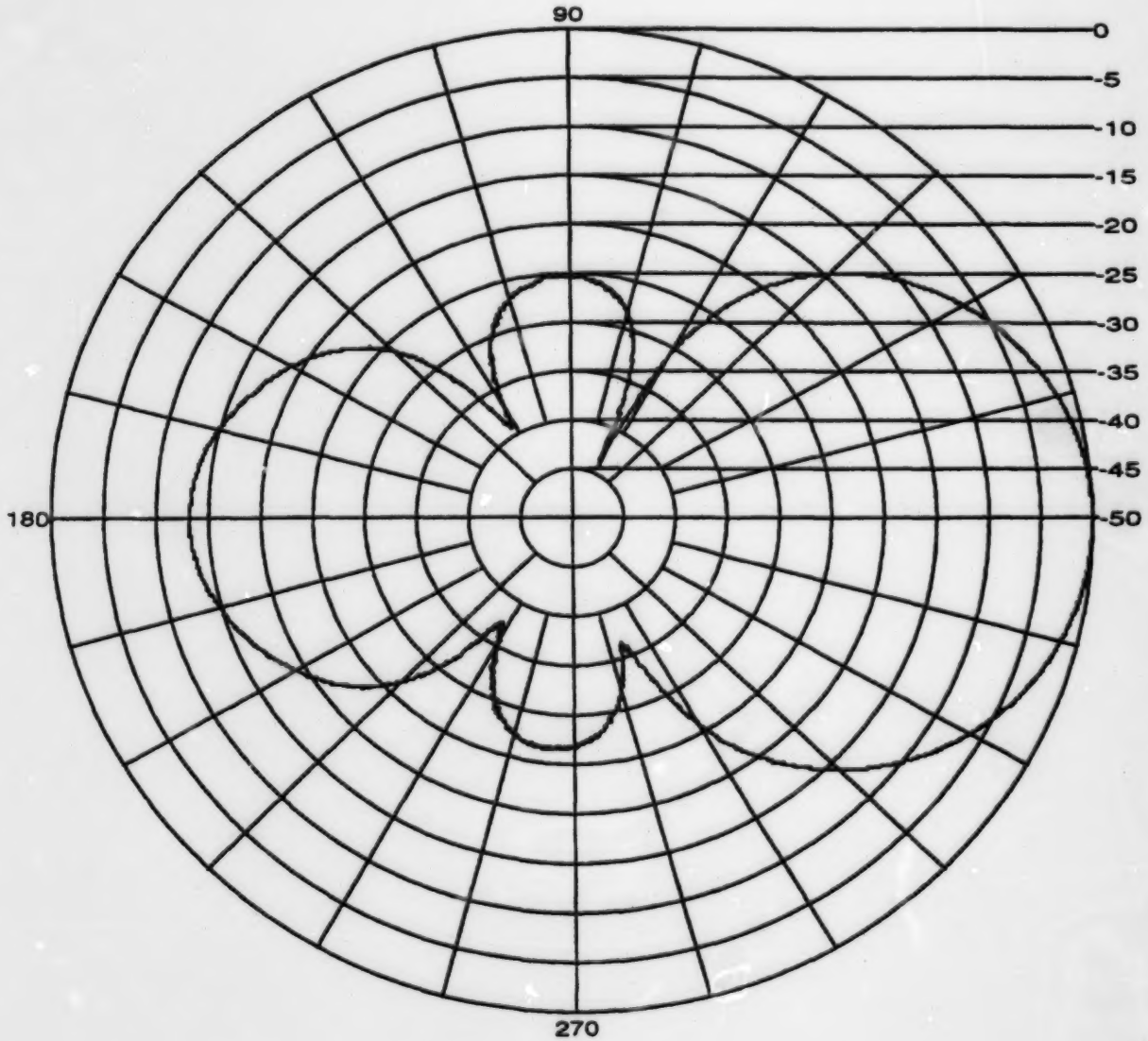
16/12/97

DIRECTIONAL RESPONSE

Transducer: F-33 #101
Owner: DREA
Comments: Fitzgerald F-33 X-Y plane

Depth: 1.83 metres
Drive voltage: 28.9 Volts
Frequency: 10.0 kiloHertz
Directivity Index: 13.16



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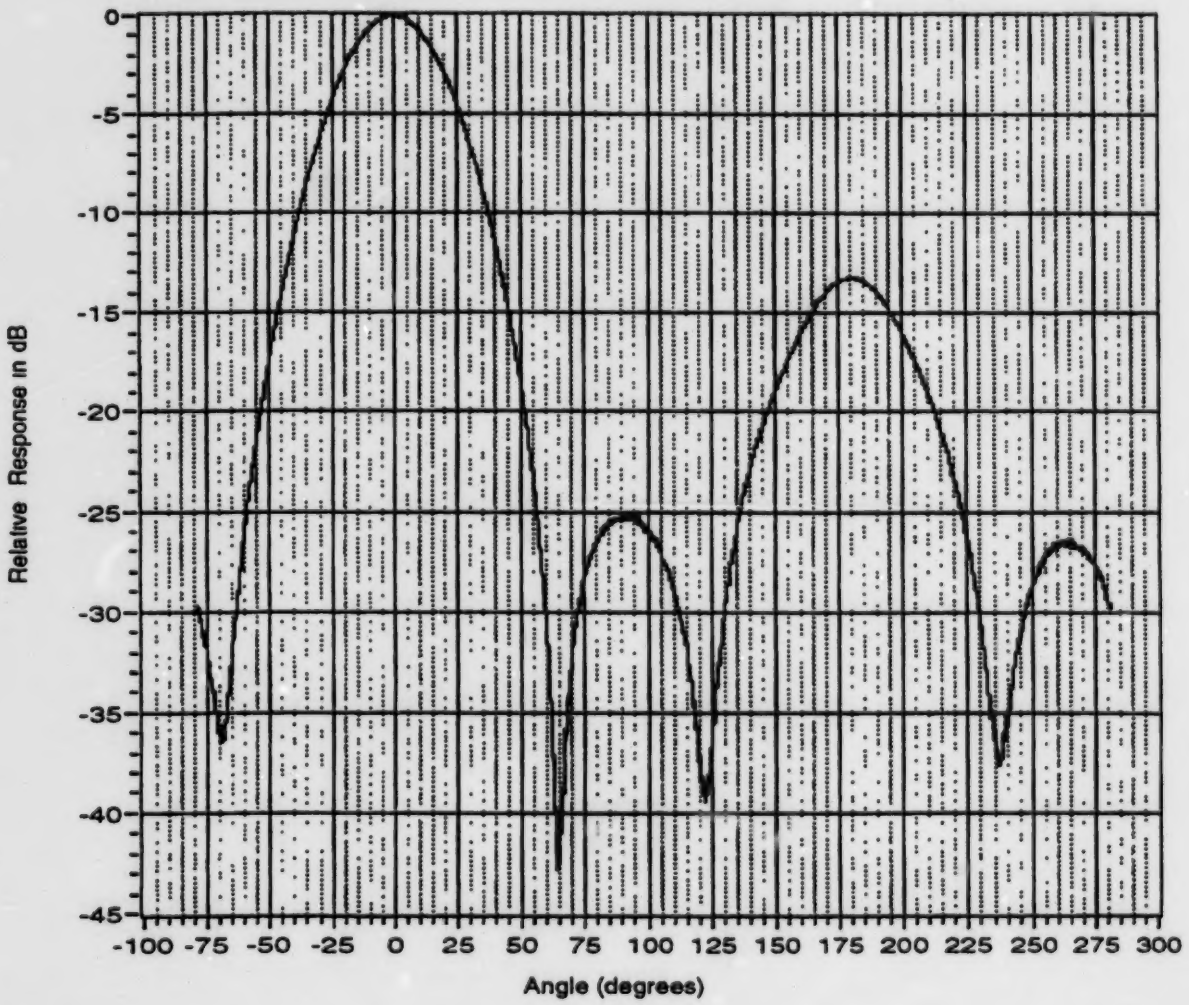
16/12/97

DIRECTIONAL RESPONSE

Transducer: F-33 #101
Owner: DREA
Comments: Fitzgerald X-Y plane

Depth: 1.83 metres
Drive voltage: 28.8 Volts
Frequency: 10.0 kiloHertz
Directivity Index: 13.16



TRANSCAL DATA FILE			
TYPE	Directional Response		
DATE	18/12/97		
OWNER	DREA		
COMMENT	Fitzgerald testing, speed = 25,		
start = 12.5 deg (Ø=0)			
PROJECTOR ID	F-33 #101		
HYDROPHONE I	B&K 8100 #806539		
DEPTH (m)	1.83		
TEMPERATURE	10		
SEPARATION (	1		
V SCALING	100		
I SCALING	1		
CAPACITANCE	1.83		
DISSIPATION	1.83		
FREQUENCY (k	10		
DIRECTIVITY IN	13.13		
HYDROPHONE	-206.79		
Angle, Ø	Hydrophone	Projector	Directional
	Voltage	Voltage	Response
(deg)	(V)	(V)	(dB re max)
0	0.965	52.585	-0.189
0.1	0.965	52.557	-0.192
0.2	0.964	52.51	-0.198
0.3	0.964	52.523	-0.203
0.4	0.966	52.565	-0.186
0.5	0.964	52.497	-0.202
0.6	0.965	52.54	-0.188
0.7	0.965	52.556	-0.189
0.8	0.965	52.519	-0.188
0.9	0.963	52.502	-0.205
1	0.965	52.616	-0.189
1.1	0.965	52.489	-0.195
1.2	0.964	52.505	-0.199
1.3	0.964	52.531	-0.203
1.4	0.963	52.569	-0.207
1.5	0.964	52.589	-0.197
1.6	0.964	52.523	-0.204
1.7	0.962	52.522	-0.213
1.8	0.963	52.505	-0.206
1.9	0.963	52.551	-0.211
2	0.963	52.607	-0.208
2.1	0.961	52.504	-0.226
2.2	0.962	52.58	-0.217

Appendix D: Sample Results for Reciprocity Mode

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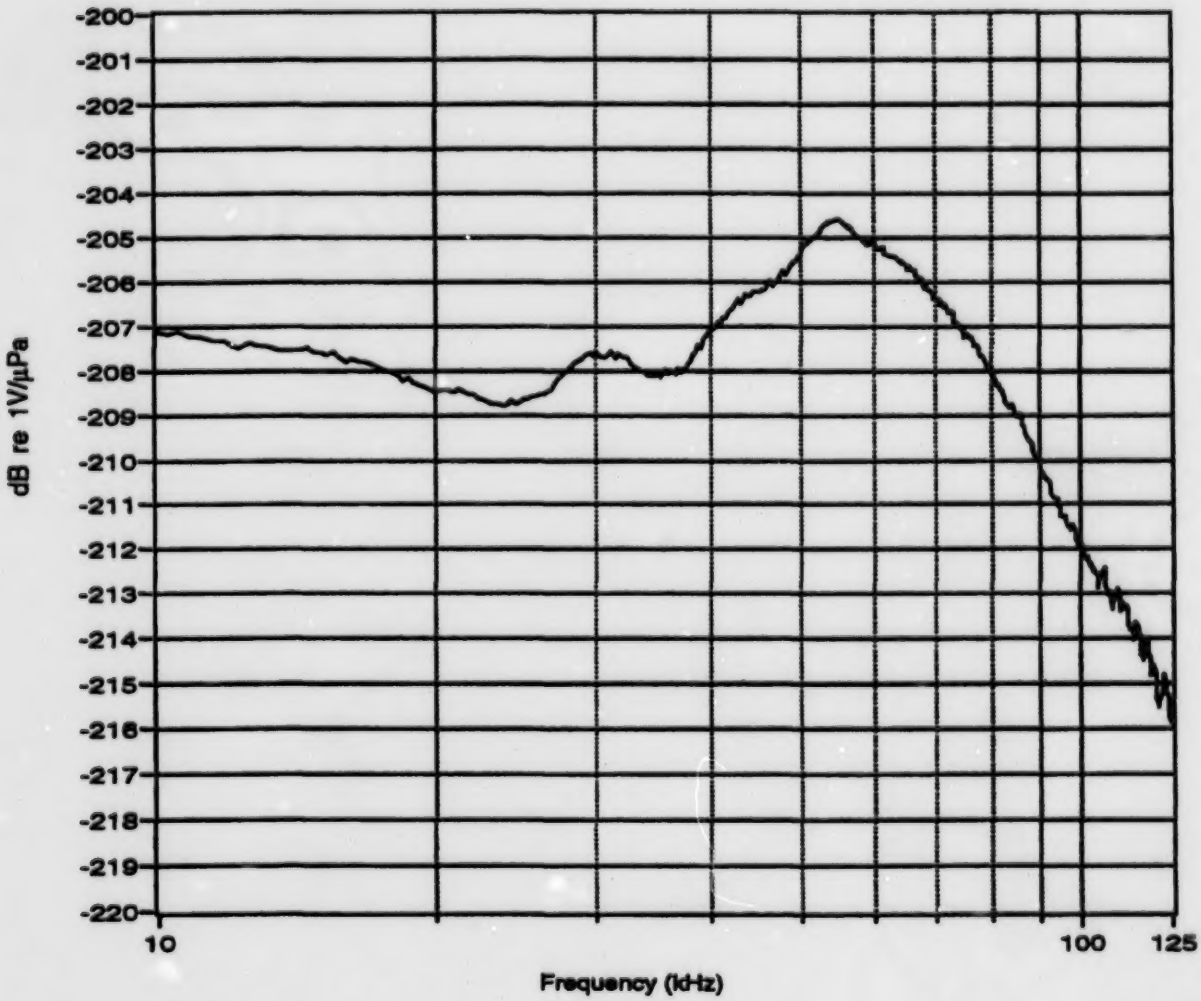
RECEIVING RESPONSE

Projector: F33 #102
Hydrophone: B&K 8106 #1900453
Reciprocal: B&K 8104 #1662518
Owner: DREA
Comments: Reciprocity cal, 8106 #452
Receive response for reciprocal transducer

Drive voltage: 71.0 Volts
Depth: 3.05 metres
Temperature: 10.00 degrees C
Hydrophone Capacitance: 1.0 nanoFarads
Cable Capacitance: 0.0 nanoFarads



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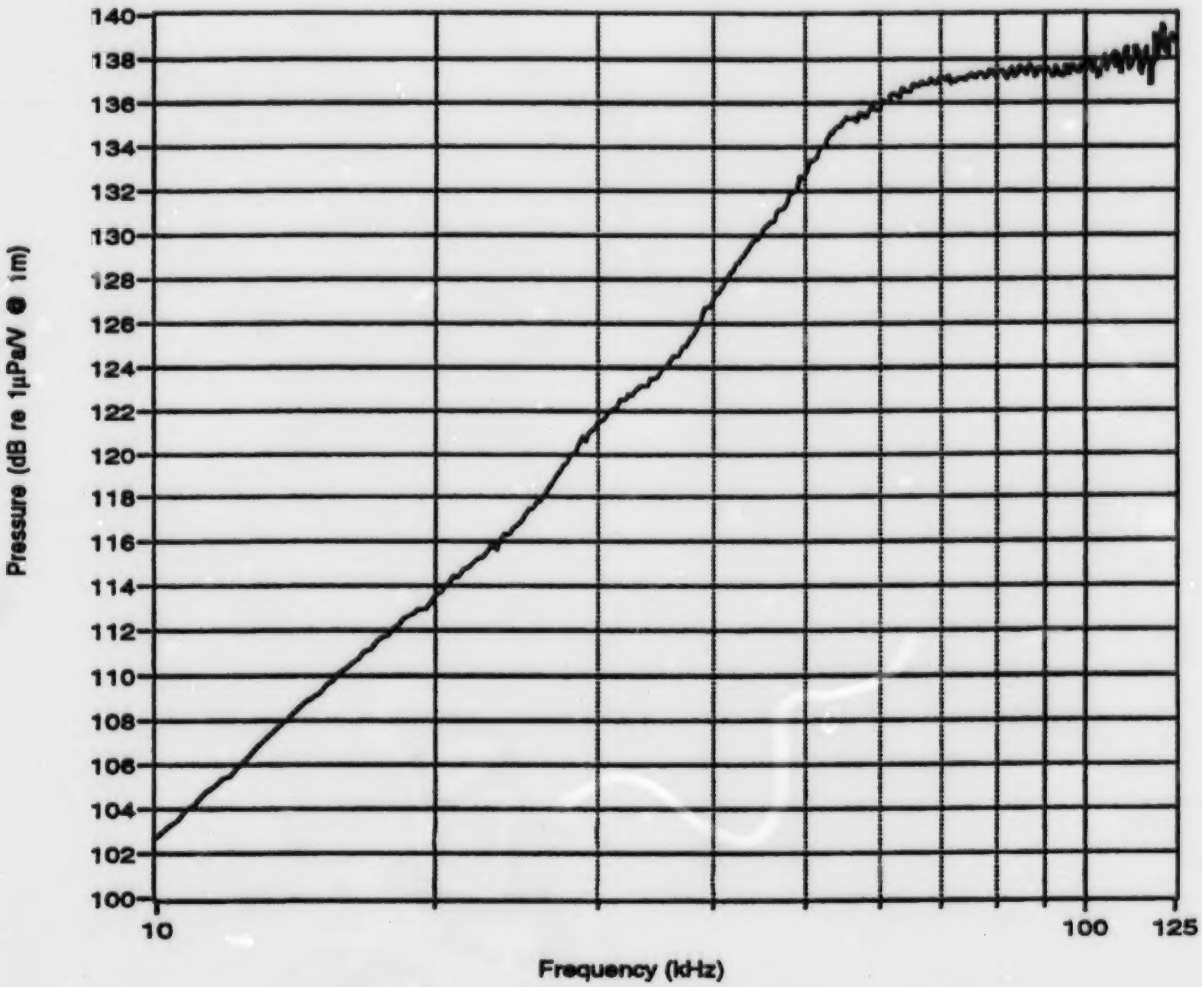
TRANSMITTING VOLTAGE RESPONSE ST

Projector: F33 #102
Hydrophone: B&K 8106 #1900453 L
Reciprocal: B&K 8104 #1662518
Owner: DREA
Comments: Reciprocity cal, 8106 #452
Transmit voltage response for reciprocal transducer

Drive voltage: 71.0 Volts
Depth: 3.05 metres
Temperature: 10.00 degrees C
Hydrophone Capacitance: 1.0 nanoFarads
Cable Capacitance: 0.0 nanoFarads



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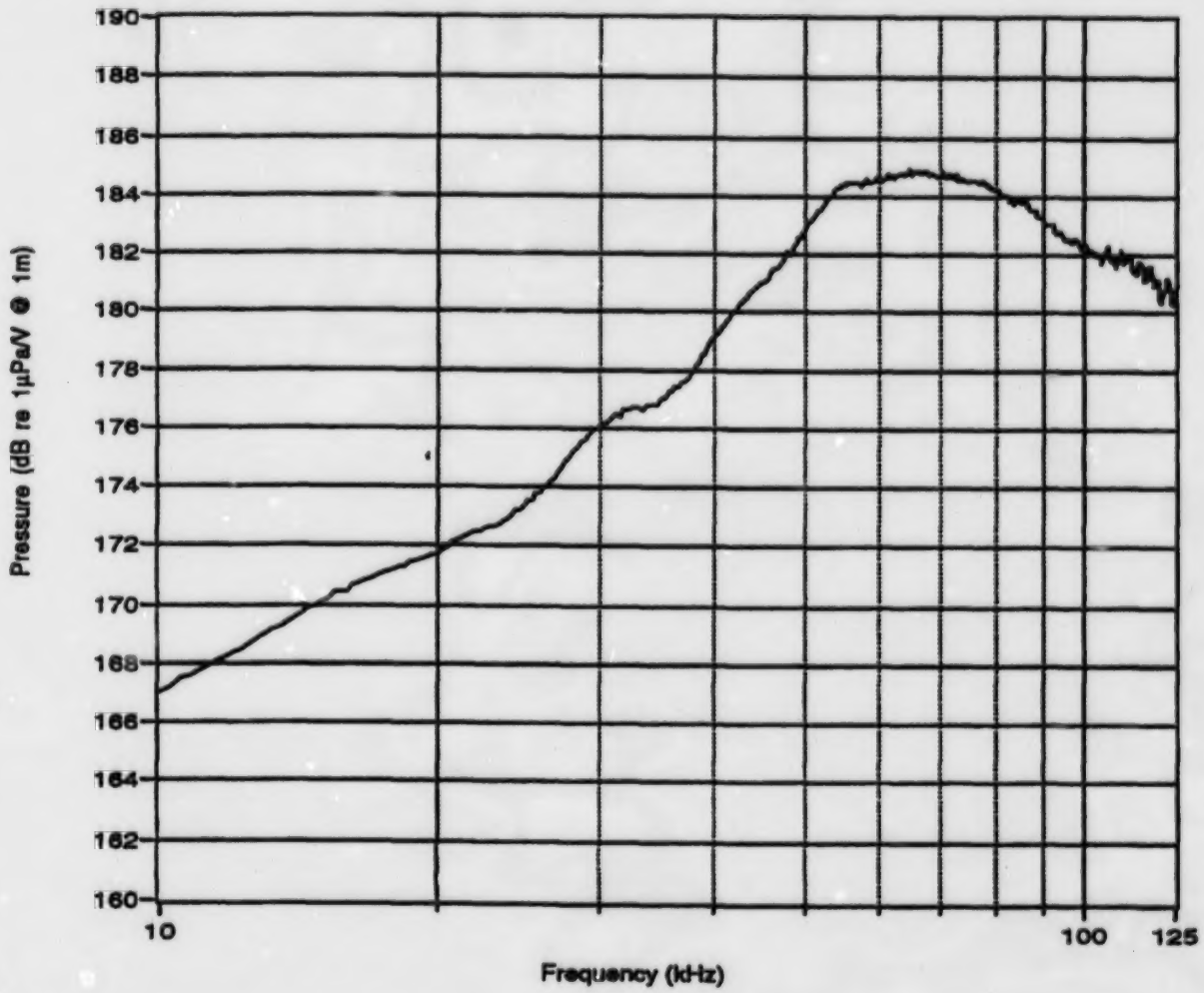
3/17/99

TRANSMITTING ~~VOLTAGE~~ CURRENT RESPONSE ST

Projector: F33 #102
Hydrophone: B&K 8106 #1900453
Reciprocal: B&K 8104 #1662518
Owner: DREA
Comments: Reciprocity cal, 8106 #452
Transmit current response for reciprocal transducer

Drive voltage: 71.0 Volts
Depth: 3.05 metres
Temperature: 10.00 degrees C
Hydrophone Capacitance: 1.0 nanoFarads
Cable Capacitance: 0.0 nanoFarads



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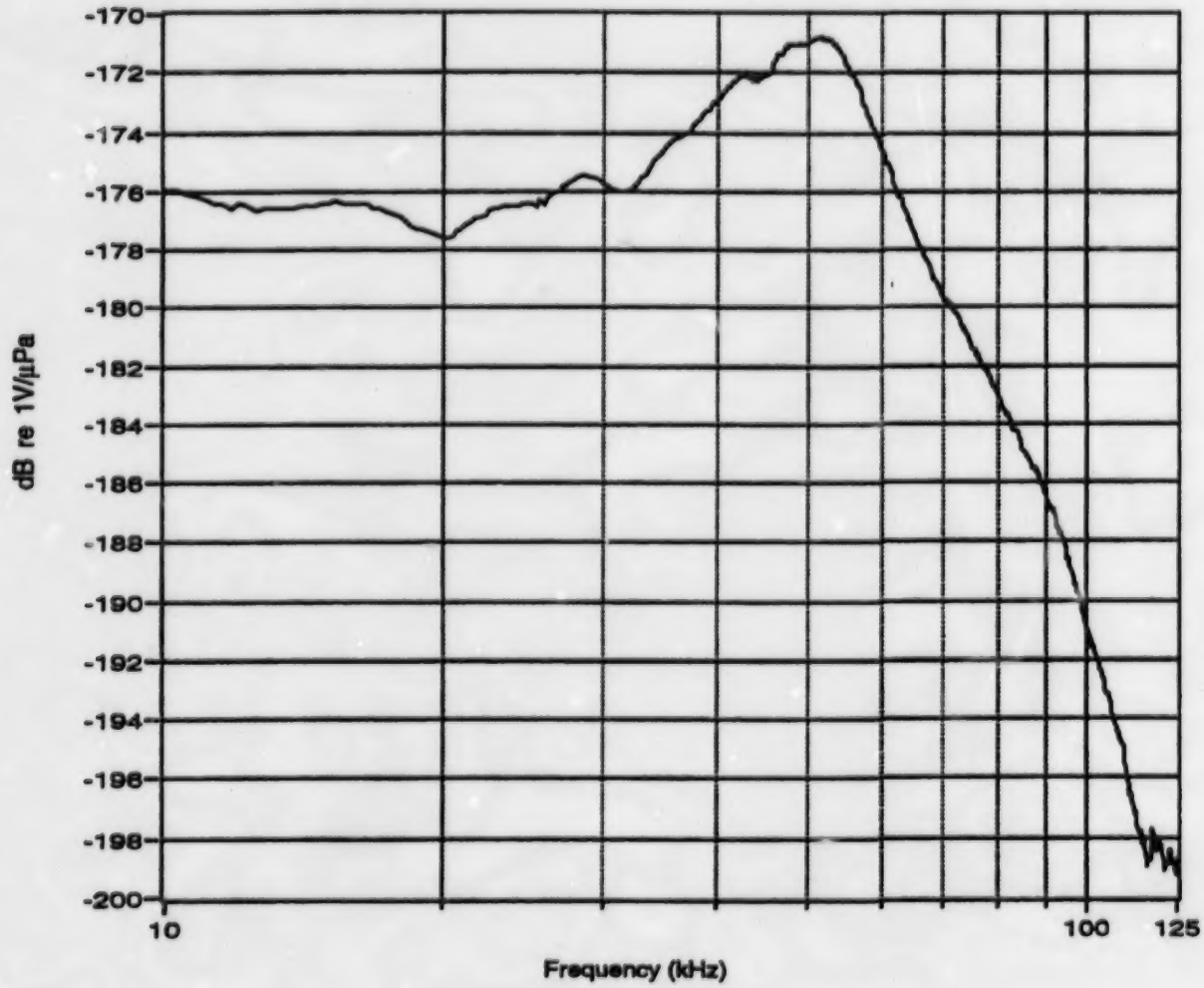
3/17/99

RECEIVING RESPONSE

Projector: F33 #102
Hydrophone: B&K 8106 #1900452
Reciprocal: B&K 8104 #1662518
Owner: DREA
Comments: Test Point A, Reciprocity
Receiving response for hydrophone under test

Drive voltage: 71.0 Volts
Depth: 3.05 metres
Temperature: 10.00 degrees C
Hydrophone Capacitance: 1.0 nanoFarads
Cable Capacitance: 0.0 nanoFarads



TRANSCAL DATA FILE														
TYPE	Reciprocity Calibration													
DATE	12/14/98													
OWNER	DREA													
COMMENT	Reciprocity on B&K 8105 #1271262.													
PROJECTOR ID	F-33 #102													
HYDROPHONE ID	B&K 8106 #452													
RECIPROCAL TRANSDUCER ID	B&K 8105 #1271262													
DEPTH (m)	3.12													
TEMPERATURE (C)	10													
T-->H SEPARATION (m)	1.275													
V SCALING	100													
I SCALING	1													
HYDROPHONE CAPACITANCE	1						✓			✓				
CABLE CAPACITANCE	0		✓											
Frequency	P-->H (1)	P-->H (1)	P-->H (1)	P-->T (2)	P-->T (2)	P-->T (2)	T-->H (3)	T-->H (3)	T-->H (3)	Mh	Mt	St		
	Voltage	Current	Eph	Voltage	Current	Ept	Voltage	Current	Eth					
(Hz)	(V)	(I)	(V)	(V)	(I)	(V)	(V)	(I)	(V)	(dB re 1V/µPa)	(dB re 1V/µPa)	(dB re 1µPa/V at 1m)		
10030.891	110.159	0.088	0.512	110.185	0.088	2.867	123.177	0.061	0.597	-180.143	-200.118	107.969		
10132.314	110.563	0.089	0.581	110.595	0.089	3.356	123.579	0.061	0.606	-180.207	-200.113	108.126		
10234.961	110.845	0.089	0.607	110.853	0 09	3.434	123.905	0.062	0.62	-180.148	-200.1	108.248		
10338.842	109.881	0.091	0.626	109 886	0.091	3.136	122.821	0.063	0.625	-180.237	-200.234	108.478		
10442.466	110.288	0.092	0.642	110.283	0.092	3.25	123.20	0.064	0.574	-180.223	-200.14	108.888		
10547.945	110.702	0.092	0.656	110.685	0.093	3.347	123.714	0.064	0 641	-180.338	-200.186	108.742		
10654.49	110.899	0.093	0.583	110.982	0.093	3.108	124.027	0.064	0.585	-180.426	-200.039	109.014		
10762.111	110.125	0.095	0.607	110.103	0.095	3.549	123.018	0.066	0.594	-180.488	-200.132	109.253		
10870.82	110.556	0.095	0.624	110.545	0.095	3.273	123.563	0.066	0.655	-180.905	-200.215	109.206		
10980.629	111.016	0.096	0.67	110.99	0 096	3.74	124.045	0.067	0.688	-180.988	-200.33	109.302		
11091.542	109.951	0.096	0.651	109.961	0.096	0.484	122.879	0.068	0.545	-175.984	-205.244	104.712		
11203.577	110.445	0.099	0.741	110.435	0.098	0.497	123.431	0.068	0.609	-176.007	-205.286	104.788		
11316.745	110.842	0.099	0.686	110.847	0.099	0.464	123.879	0.068	0.543	-175.938	-205.277	104.873		
11431.056	109.905	0.1	0.776	109.944	0.101	0.521	122.855	0.07	0.613	-175.982	-205.447	105.058		
11546.521	110.455	0.101	0.695	110.512	0.101	0.536	123.456	0.07	0.61	-176.144	-205.398	105.135		
11663.152	110.837	0.102	0.706	110.845	0.102	0.478	123.929	0.07	0.559	-176.013	-205.403	105.207		
11780.962	110.049	0.104	0.723	110.067	0.104	0.489	123.001	0.072	0.624	-176.164	-205.554	105.367		
11899.961	110.044	0.104	0.649	110.03	0.104	0.497	123.59	0.072	0.578	-176.126	-205.449	105.904		
12020.163	110.781	0.105	0.735	110.789	0.105	0.5	123.786	0.073	0.578	-176.189	-205.529	105.884		
12141.579	111.033	0.106	0.644	111.075	0.106	0.51	124.084	0.074	0.658	-176.194	-205.563	105.902		
12264.221	110.072	0.108	0.761	110.103	0.108	0.507	122.984	0.075	0.593	-176.381	-205.514	106.158		
12388.102	110.253	0.109	0.757	110.247	0.109	0.524	123.19	0.076	0.606	-176.345	-205.543	106.3		
12513.234	110.486	0.109	0.763	110.521	0.109	0.471	123.454	0.076	0.621	-176.329	-205.512	106.465		
12639.631	110.77	0.111	0.686	110.738	0.11	0.531	123.708	0.077	0.549	-176.419	-205.636	106.475		
12767.304	111.036	0.111	0.772	110.986	0.111	0.536	124.018	0.077	0.558	-176.445	-205.614	106.615		
12896.267	110.09	0.113	0.774	110.11	0.113	0.48	122.981	0.079	0.647	-176.432	-205.568	106.969		
13026.531	110.321	0.114	0.771	110.317	0.114	0.482	123.241	0.08	0.657	-176.478	-205.58	107.132		
13158.112	110.007	0.115	0.697	110.007	0.115	0.536	123.585	0.08	0.668	-176.41	-205.667	107.183		
13291.023	110.082	0.116	0.691	110.068	0.116	0.485	123.928	0.081	0.588	-176.816	-205.682	107.245		
13425.275	111.278	0.117	0.692	111.284	0.116	0.485	124.298	0.081	0.585	-176.817	-205.71	107.327		
13560.886	110.386	0.116	0.694	110.321	0.116	0.492	123.258	0.083	0.678	-176.76	-205.746	107.894		
13697.863	110.052	0.119	0.667	110.063	0.12	0.495	123.569	0.084	0.668	-176.864	-205.716	107.828		
13836.226	110.063	0.121	0.69	110.079	0.12	0.442	123.945	0.084	0.619	-176.761	-205.629	107.833		
13976.995	109.997	0.122	0.707	109.973	0.122	0.448	122.853	0.086	0.632	-176.844	-205.697	108.177		
14117.167	110.386	0.123	0.646	110.384	0.123	0.449	123.314	0.086	0.638	-176.77	-205.823	108.163		
14258.756	110.831	0.124	0.651	110.85	0.124	0.406	123.809	0.087	0.652	-176.813	-205.876	108.357		
14403.782	111.007	0.125	0.666	111.008	0 125	0.46	124.014	0.087	0.587	-176.855	-205.884	108.421		

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This report is a user manual for the transducer calibration software, referred to as TRANSCAL, for use in the Defence Research Establishment Atlantic (DREA) calibration facilities. This software was developed in three phases. In Phase 1, procedures for the transmitting voltage response and receiving response using swept pulse or continuous wave (CW) were developed. In Phase 2, additional calibration procedures were added for directional response measurements and reciprocity measurements. An interface to a servomotor control system for elevation positioning was added. Also in Phase 2, the existing Brickwall filter was replaced by a Krohn-Hite Model 3988 filter, resulting in software modifications. The user interface front panels were re-designed to enable use of 17-inch display. In Phase 3, a standalone admittance/impedance measurement mode was added. The user manual was revised to include the new measurement mode, as well as consolidate the user manuals resulting from the two previous phases.

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